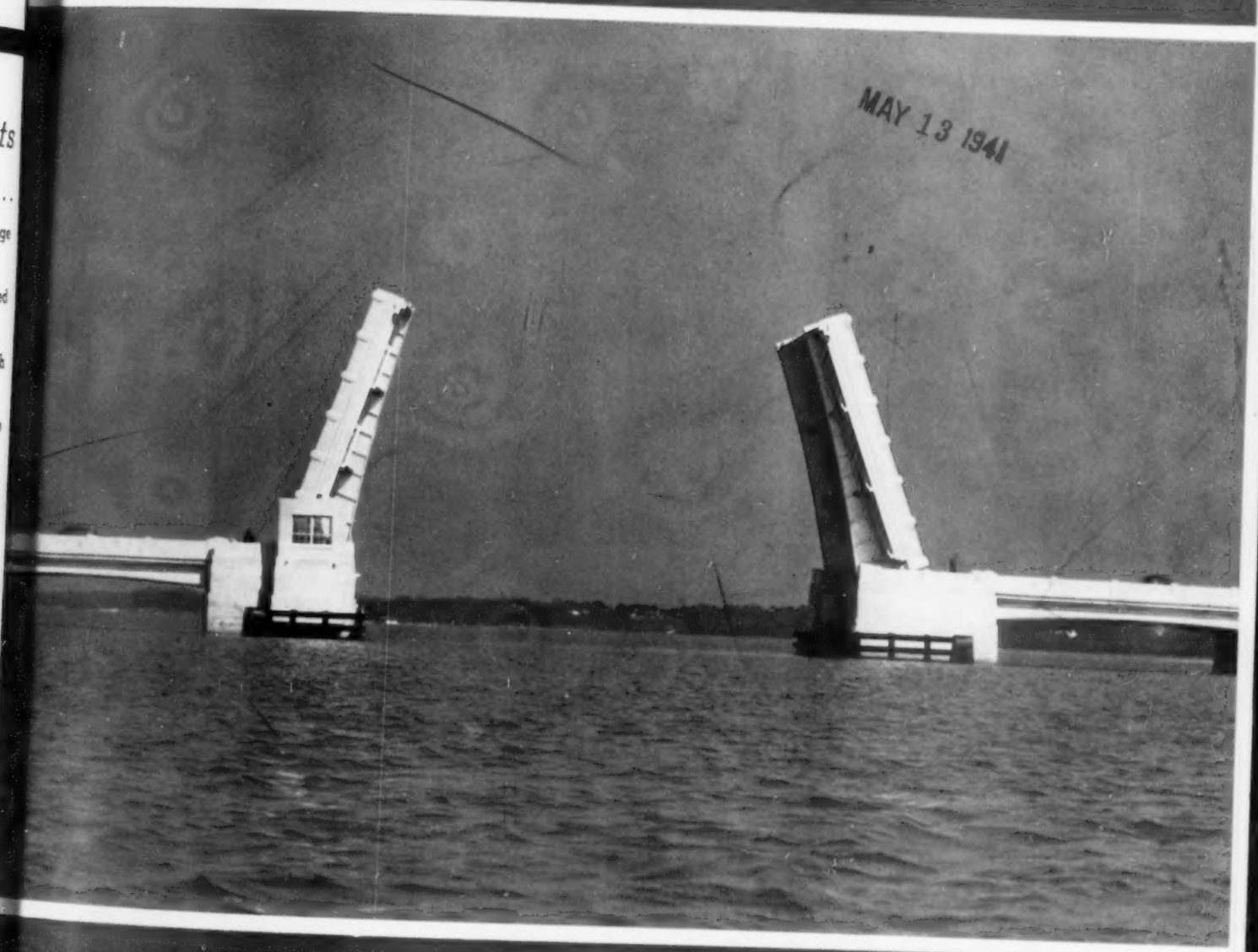
MAY 1941

The WELDING Journal



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The Journal of the American Welding Society

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GENERAL ELECTRIC

Welding Journal
VOLUME 20, No. 5
MAY, 1941

Shall We Weld Our Bridges?*

By Fred L. Plummer†

LET us assume that you, as a structural engineer, have today been made responsible for supervising the design and construction of an important bridge. Let us assume, further, that conditions at the site and service requirements are such that a steel structure will be most economical and that the indicated type of structure is one which could be fabricated by welding. Would you seriously consider the use of this method of fabrication? The writer is convinced that relatively few of you would do so. Why is this so when welding is generally accepted as an efficient, safe and economical method of fabricating almost every other variety of structures and machines? Machines, large and small, subjected to severe service conditions and heavy impact loads; ships and other vehicles for transportation in the air or on land and sea; pressure vessels and piping subjected to extreme temperature variations, highly corrosive action and terrific pressures are all welded.

Why, then, should we hesitate to fabricate bridges by welding? They are, in general, subject to much less severe service conditions than many of these other types of structures. Is it because we lack properly equipped fabricating shops? Yes, to some extent. Large fabricators are naturally reluctant to make major and expensive changes in their plant layouts. George F. Wolfe of Dravo Corporation has described how the Pittsburgh plant of that corporation has over a period of five years changed from a production of more than 90 per cent riveted construction to one of more than 90 per cent welded construction. During 1939 the plant constructed 136 boat hulls—every one of welded construction. This production required major and drastic changes in equipment and in the division of shop areas for the various fabricating processes. These expensive changes have, however, yielded handsome dividends in increased economies and efficiency. Many other structural shops have established similar records and it seems probable that the larger fabricators will make the necessary changes as soon as the demand for welded fabrication justifies such changes.

Are we reluctant to weld bridges because much of the fabrication must be done in the field under adverse conditions, extremes of heat and cold, rain, wind; use of portable self-contained units, no positioning of welds, welders in precarious positions not conducive to the making of good welds; high labor and insurance rates, handicapping union rules, frequently an inadequate supply of qualified union welders? All of these factors are important problems which must be met. The fabricators and erectors of storage tanks, pipe lines and similar structures successfully solve them every day.

Have our engineers been overcautious, ultraconservative, perhaps a little lazy in learning the possibilities and the limitations of this versatile and relatively new method of fabrication? Bridges are usually built for railroads or public agencies—state, county or city. The engineers for these groups are properly very conservative. Public safety is involved. A bridge failure might result in a heavy loss of life. The public, having no means of measuring the true monetary value of a bridge, gives little credit to its engineers if they save a few thousand dollars on a given construction project. They are, however, quick and loud in their condemnation if even a minor failure of this structure results. In consequence economy is not a major controlling factor as it may be to a larger extent in construction for private interests.

Are we prevented from welding bridge structures by the many shop difficulties due to mill variations in rolled sections, distortions caused by the heat of welding,

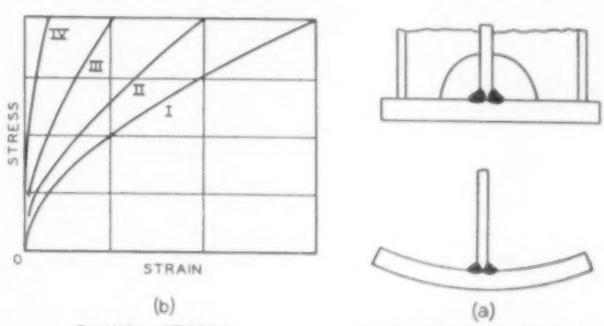

Fig. 1

improper design instructions? The universally used lap joint of riveted construction prevents the accumulation of errors due to fabrication or mill variation. The more desirable butt joint of welded construction does not provide a similar convenient correction. Detailers trained to layout riveted joints may not call for welded assemblies which can be properly and economically constructed in the shop unless they have familiarized themselves with welding procedures. Frequently unnecessary welds, too large welds and too many weld sizes are specified. Sometimes too little information is given, forcing the

* Presented at the Annual Meeting, A. W. S., Cleveland, Ohio, Oct. 21 to 25, 1940.

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welder or his supervisor to make decisions concerning design for which he is not trained or qualified.

All of these and other factors would probably influence your answer to the question raised at the beginning of this discussion. Before submitting your final answer let us review together a few of the more recent failures and successes of welded bridges designed by other engineers.

In this country complete plans and specifications are usually prepared by the engineers representing the owners for whom a given bridge is to be built. Fabricating and erection firms can only bid on the specified type of construction. In Europe, engineers for the owners frequently specify service requirements only. In consequence, contracting firms can prepare designs for alternate types of construction favoring that which they are equipped to construct most economically. This condition encourages the introduction of new and more economical forms of construction. In consequence, we find the use of welded bridges much more advanced in Europe than in this country.

Welding has been widely used in this country and abroad for the reinforcing of old bridges which are overloaded either because of deterioration or increase in loads. We will discuss only one such application since we are primarily interested in the construction of new bridges. The 458-foot span arches of the Austerlitz Bridge at Paris (THE WELDING JOURNAL, May 1939) carried 700 trains daily. It was designed in 1903 to support trains weighing less than one-third of the typical Metropolitan train now in use. These arches were seriously overloaded due to this increase in the weight of trains. To relieve this condition 280 tons of steel, about one-third of the weight of the original bridge, were added while the bridge remained in service. The work was carefully planned and successfully executed. The Schmuckler test (described later) was used to inspect the texture, fusion and penetration of the welds.

During the past several years, Germany has built 150 railway and 500 highway bridges of welded construction (THE WELDING JOURNAL, August 1939). All of these with two exceptions have given perfect service. Several have been carefully inspected after a few years of service and show no signs of deterioration. The two exceptions are the Zoo Station Railway bridge in Berlin and the Rüdersdorf highway bridge. Both of these are plate girder bridges and in each a serious crack developed in the web of a girder starting at the weld joining the web and flange plates. In the first case, the failure seemed to be caused by an excessive concentration of alloy elements in the weld resulting in weld metal of very low ductility. In the second case the weld metal showed good ductility; however, a brittle condition was created by biaxial stresses consisting of the normal longitudinal stresses in the tension flange and of cross stresses due to welding. The stiffeners had been placed before the web-to-flange weld had been made (see Fig. 1 (*a*)). After

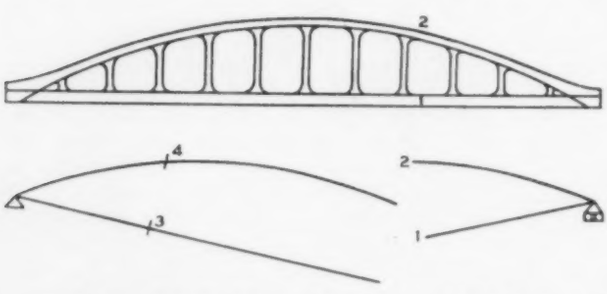

Fig. 2—Hasselt Bridge Failure. Breaks Occurred in Order and at Locations Shown

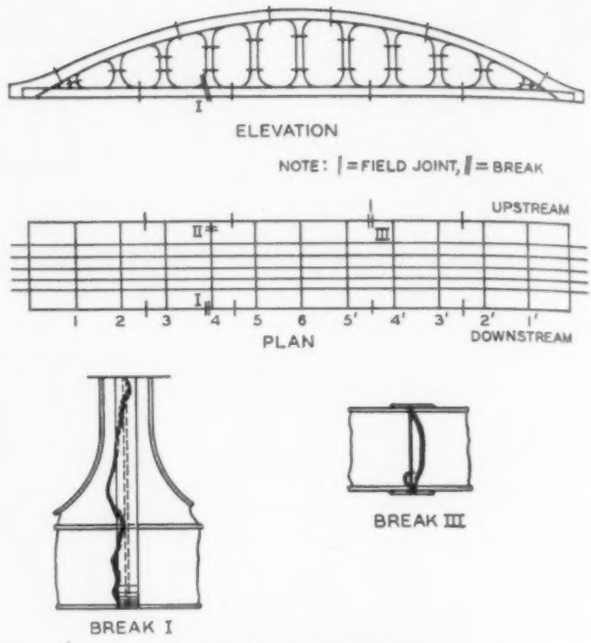

Fig. 3—Hérenthals-Oolen Bridge

the web crack developed some of the stiffeners were cut and the flanges curled up enough to indicate that a cross-tension stress of approximately 25,600 lb. per square inch had existed. The effect of biaxial stresses upon deformation is shown qualitatively in Fig. 1 (*b*). Curve I shows a stress-strain curve for steel subjected to a pure tension stress, *S*. If the steel must resist other tension stresses perpendicular to the direction in which *S* acts and equal in intensity to $^1/_4$, $^1/_2$ and $^3/_4$ of *S*, curves II, III and IV show the resulting deformation. As the two stresses approach each other in intensity there is less deformation before fracture, the material acting like a brittle material. Experience of the Germans would indicate that: (1) heating effects shall be minimized as much as possible; (2) plates thicker than two inches should not be used; (3) T-shaped flanges should be used for welded girders in order to avoid the shrinkage effect just noted.

The most serious welded bridge failure to date was the Hasselt Bridge in Belgium, built in 1936. This was a highway bridge carrying one street-car track. The bridge was supported by two 245-foot span Vierendeel trusses with parabolic top chords. On March 13, 1938, after the bridge had been in service one and one-half years, a large crowd gathered on the bridge to watch a bicycle race on the bank of the canal which the bridge crosses. The following morning just after two street cars had followed each other across the bridge, the watchman heard a loud detonation and saw a crack forming in the lower chord of the truss. When the lower chord failed, the upper chord acted as an arch, the upper parts of the abutments resisting the thrust for a few minutes. When these failed the bridge fell into the canal, each truss breaking into three pieces, as shown in Fig. 2. The failure took place over a period of six minutes and everyone escaped without injury from the structure. Factors which probably contributed to the failure of this structure include: the use of very thick plates of questionable weldability in the built-up chord sections; the presence of large locked-up stresses due to many heavy welds, some superfluous welds and lack of proper sequence in making welds; inaccurate assembly resulting in the necessity for heavy field welds; and possibly the use of welders with too little experience.

Two other welded bridge failures have occurred in Belgium. Possibly because they occurred after the outbreak of the present war they have received little attention in this country. However, both failures occurred before the invasion of Belgium and were not due to any wartime service requirements.

The bridge of Hérenthals-Oolen across the Albert Canal was constructed in 1936 and 1937. The bridge is supported by two Vierendeel trusses of approximately 200-foot span with parabolic upper chords. The roadway is 31 feet wide with railway tracks. The lower chords of the trusses consisted of three plates welded together to form an I section. This central span included floor expansion joints similar to those used in the bridge at Hasselt.

About 2:30 A.M. on Jan. 19, 1940, the sentinels who guarded this bridge heard three loud reports but owing to the severe weather conditions did not at that time investigate. Shortly after daybreak an engine and two cars passed over the bridge. A little later agents of the bridge department discovered that the two lower chords of the trusses were broken. Figure 3 shows an elevation and plan of the structure with the three breaks indicated. At *I* the lower chord was broken at the left of vertical 4 in the downstream truss. The break at *II* occurred in the floorbeam connecting the same verticals 4, and near the upstream truss. Break *III* occurred in the lower chord of the upstream truss about the middle of panel 7–8, at a section where the chord had been spliced, although the break did not follow the weld through the web plate. The extent of breaks *I* and *II* is shown in Fig. 3. It is thought that break *I* occurred first.

It seems probable that the extremely cold weather which had continued for several days prior to the accident was the final cause of the breaks. At the very low temperatures which existed at that time the steel was less ductile and the internal stresses created by restraint when the welds were made were added to the secondary stresses due to the variation in temperature. Both of the breaks in the lower chords occurred in panels where there were floor expansion joints.

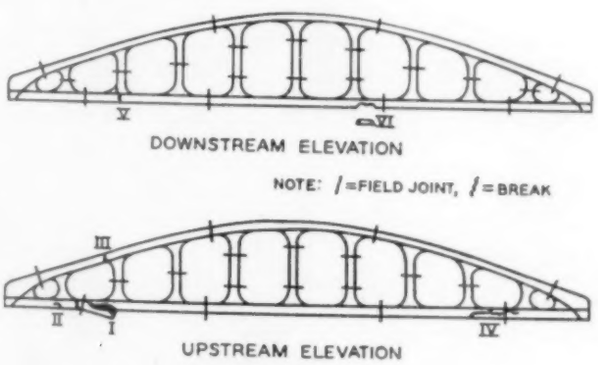

Fig. 4—Kaulille Bridge

The bridge at Kaulille across the Jonction Canal was constructed in 1934 and 1935. The type of structure is the same as that at Hasselt with a span of only 160 feet and a width of 30 feet. The lower chord of the Vierendeel trusses consist of rolled beams rather than of the welded sections used for the two other bridges. There are two expansion joints in the floor slab; however the stringers are continuous. This bridge was built earlier than the two others and had been in service over five years when it failed just six days after the failure of the bridge at Hérenthals-Oolen.

Figure 4 shows elevations of the upstream and downstream trusses with the location and character of the various breaks shown. Remember that the lower chords of this bridge consist of rolled sections and that the floor expansion joints extend through the floor slab only, and yet note that each lower chord is broken in two places. Breaks *I* and *V* are believed to be the first to occur. Note also that the breaks did not in general occur in or even near the welded joints which are indicated in Fig. 4. In this case also, low temperatures are blamed for the actual failure. Neither of these last two failures resulted in the collapse of the respective bridge structures.

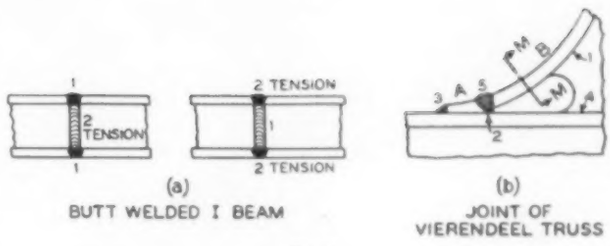

Fig. 5

F. Hecq in the February 1940 issue of the Belgium magazine, *L'Ossature Metallique*, gives an interesting discussion of the technique of welding in Belgium "before" and "after" the failure of the bridge at Hasselt. He emphasizes the great importance, in developing locked up stresses, of the order in which the welds for a given joint are completed and also the order in which the various joints of the complete truss are welded. Figure 5 (*a*) illustrates the simple case of a butt-welded I beam. If the flanges are welded first, welding of the web will create tension stress in the web weld as it cools and compression stresses in the flanges. If the order of welding is reversed, tension stresses will be created in the flanges whereas the web will be subjected to compression stress.

Figure 5 (*b*) shows the more complex joint commonly used in connecting the vertical member to the lower chord of a Vierendeel truss. The numbers 1 to 5 indicate the order in which the welds were made for the bridge at Hasselt and for most of the other earlier Vierendeel trusses. Obviously the heavy flanges *A* and *B* were both tied rigidly to the lower chord before the weld 6 was made. As a result an important tension stress across section *M-M* was created and offset by a comparable compression in the chord member. Following the failure of the bridge at Hasselt one contractor cut a similar joint at section *M-M* and found that a tension stress of the order of 14,000 lb. per sq. in. had been created by such a procedure.

Failures are usually the result of the combined effects of a number of unfavorable factors. The initial break in the Hasselt bridge occurred in a joint of the above type, where the welds were of inferior quality and where a number of welds were concentrated creating a triaxial

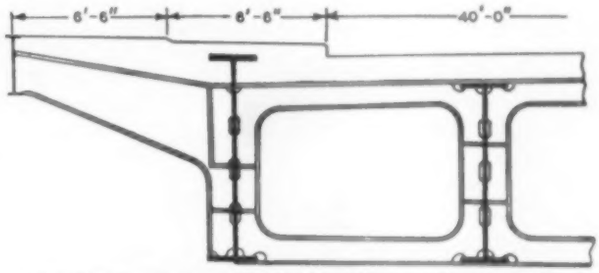

Fig. 6—Cross Section of Bridge Over Meuse at Ougrée, Belgium

Fig. 6 (*a*) Cross-Frame with Cut-Outs

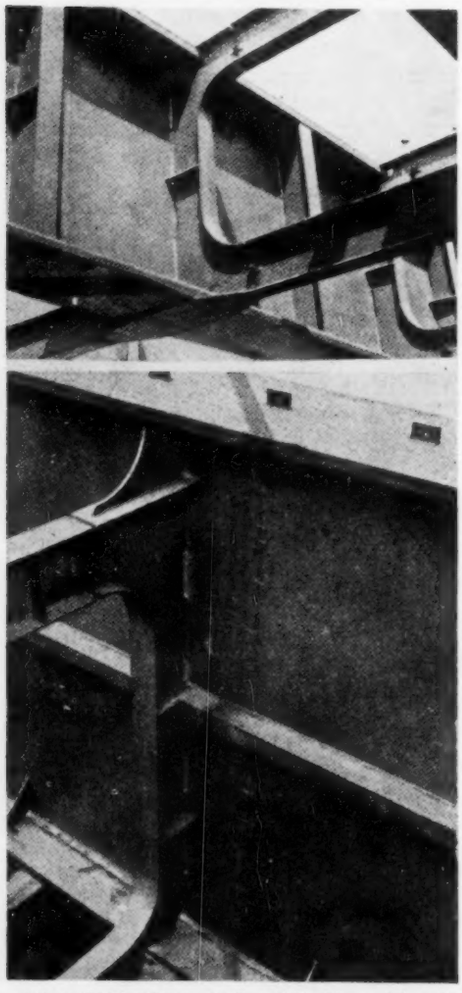

Fig. 6 (*b*)—A Butt-Welded Girder Splice of the Meuse River Bridge. Tension Flange Welds Showed 45° After German Practice. (Erection Clips Have Been Removed from Webs)

Note diagonal weld of girder flange and cut-outs

state of stress and reducing the effective ductility of the metal. It is sometimes possible to so plan the welding procedure that the resulting locked-in stresses will be beneficial rather than detrimental. These failures indicate the necessity for observing the following rules: (1) use metal of assured weldability (low carbon steel not thicker than one and one-half inches); (2) keep assemblies as flexible as possible and avoid all irregularities; (3) do not use welds heavier than necessary; (4) fabricate and assemble so as to ensure accurate fit; (5) plan a definite and proper sequence for welds in all major joints; (6) do not attempt to deposit too much weld metal at one pass with a large diameter rod and heavy current.

A recent excellent example of the application of these rules is the highway bridge which has been constructed over the Meuse River at Ougrée, Belgium. This is (or, at least, was prior to the German invasion) a three-span plate girder bridge with six lines of girders. The center span is about 213 feet long and consists of a suspended span 138 feet long, supported on two symmetrical cantilever arms which are built continuous with the side spans, which are each 166 feet long. The flanges of the girders consist of single plates 24 inches wide and varying in thickness from one to three inches with a rolled-in rib which provides for easy assembly of the web and elimination of cross-bending stresses in the flange due to welding. The web plates vary in depth from 79 to 118 inches and in thickness from 0.55 to 0.67 inch. The steel consisted of a special composition giving from 60 to 70,000 lb. per sq. in. ultimate strength, an elastic limit of 34,000 lb. per sq. in. and elongation of 20 per cent. The side span girders were fabricated in three pieces from 52 to 82 feet long and the suspended span girders in two pieces.

As shown in Fig. 6 the girders are tied together with cross-frames, spaced 8 feet apart, and supporting a roadway 40 feet wide with sidewalks and bicycle paths each $6^1/_2$ feet wide on either side of the roadway, giving a total width of bridge of about 66 feet. The cantilever brackets supporting the sidewalks are located at alternate cross-frames.

Great care was exercised to avoid concentration and intersection of welds by cutting out round or oval holes in the gusset plates connecting the cross members. These may be noted in Fig. 6 and the accompanying photographs. In order to reduce the locked-up tensions due to welding and to avoid undesirable deformations the order of making the various welds was carefully studied and specified. Single V butt joints in the girder flanges were inclined 45 degrees with the axis of the girder (see Fig. 6 (*b*)). Vertical web splices were double V butt welds and neither these nor the flange splices were reinforced with plates. Preheating was used in certain cases to prevent severe locked-up stresses.

Welds were inspected by X-rays and showed excellent qualities. Test specimens were also cut out and subjected to fatigue tests. These tests also gave satisfactory results.

One of the most important attempts made to date to design a railroad truss bridge in accordance with the requirements of welded fabrication resulted in the construction at Joncherolles near Paris of the bridge shown in Fig. 7. This single track, skew, railroad bridge is supported by two Warren type trusses having a span of 131 feet. This type of truss was selected in order to reduce to two the number of web members which had to be connected to the chord members at each panel point and also in order to keep to a minimum the secondary stresses due to truss distortions.

Figure 8 shows the types of members used for upper and lower chords and for the diagonals. Note that the lower chord which is always subjected to tension stresses consists of a plate section. The flexibility of this member further reduces secondary stress effects. The main plate is $18^1/_2$ inches wide by $1^1/_2$ inches thick. It is reinforced with two smaller plates in order to safely carry the greater stresses in interior panels. The upper chord consists of a

Fig. 7—Joncherolles Welded Truss Railway Bridge

rolled beam reinforced with four plates in the interior panels. The diagonals consist of a smaller rolled beam reinforced with two half beams cut as shown in Fig. 8. With members of this type it was possible to keep the four webs of the upper chords and diagonals in the same planes and so simplify the joints. The use of four web members further resulted in welds of small section and the transmission of load at the joints over the entire width of the adjoining member. Small gusset plates were formed to follow the normal lines of stress. All joints were butt welded.

The two trusses, which were about 15 feet deep, were completely shop fabricated. Special wheels were used for positioning the trusses during fabrication. The failure of the Hasselt bridge occurred while the trusses were being fabricated. As a consequence of this failure it was decided to test the two trusses before shipping them to the site for field erection. After the trusses had been completed they were placed in a horizontal position with the two lower chords adjacent to each other. Bearings were placed at the ends, and frames, with hydraulic jacks, were installed at each panel point. In this manner measured loads could be applied at these points. The resulting strains in various parts of the gusset plates and members were measured with extensometers. The results of the tests were entirely satisfactory and indicated normal stress distributions.

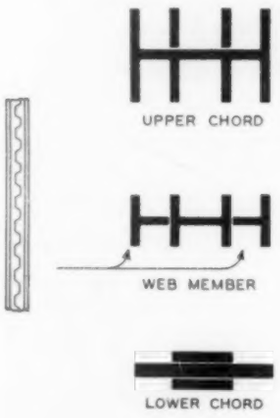

Fig. 8—Joncherolles Bridge. Truss Member Sections

It was necessary to construct special cars in order to transport the completed trusses to the site for erection. The trusses were erected over four railroad tracks with only three hours' interruption of traffic on these tracks.

These trusses are the result of logical welded designs and include the application of a number of original ideas. They merit careful study.

The construction of the Albert Canal in Belgium made necessary the building of 66 bridges. Of these 66 bridges, 54 were constructed of steel, ten being part welded and part riveted, whereas 23 were fabricated entirely by welding. Twenty of these all-welded bridges consisted of Vierendeel trusses of the same general type as those at Hasselt, Hérenthals-Oolen and Kaulille. This type of truss has been very popular in Belgium and other European countries but has not been used for main bridge structures in this country. When the upper chord of this type of truss follows a parabolic curve, it acts as a tied arch under uniformly distributed loads, the upper chord forming the arch and the lower chord the tension tie with the verticals acting as hangers to carry the loads to the upper chord. Under the action of unsymmetrical live loads the various members are subjected to bending moments. Secondary bending moments of considerable magnitude may also be created by the deflection of such trusses.

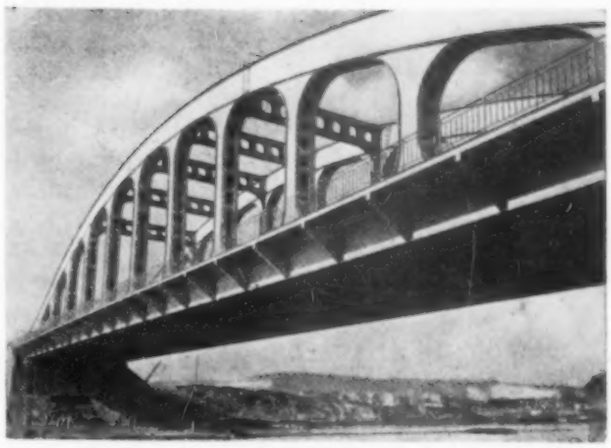

Fig. 9—Haccourt Vierendeel Truss Highway Bridge, Belgium

The Haccourt highway bridge with a span of 295 feet is typical of the Vierendeel truss bridges built over the Albert Canal during the period from 1930 to 1938. This bridge, which is constructed with some 900 tons of steel, is shown in Fig. 9. The bridge over which passes the principal road from Liége to Visé has a roadway 30 feet wide between the trusses and five-foot sidewalks cantilevered outside the trusses on either side of the bridge. The twelve-panel Vierendeel trusses have a parabolic upper chord and an over-all height of 40 feet at the center of the span. The main members are box sections consisting of beams spaced 28 1/2 inches apart and joined by plates.

The bridge is said to have a very pleasing appearance because of the curve of the upper chord, the good proportions of the various members and the unity of conception followed throughout its construction.

H. W. Clark has recently described an all-welded railway bridge constructed at Hainault in England (THE WELDING JOURNAL, July 1940). This bridge is the second welded railroad bridge to be built in England following two years after the first which was completed in August 1938. "It is estimated that a saving in weight of approximately 20% in comparison with a similar riveted design was made, and considerable economy in maintenance, reduction in corrosion and increase in life should follow." The heavy main girders consist of a web plate 67 inches deep and 1/2 inch thick welded to the flange plates, which were 18 inches wide by 2 1/2

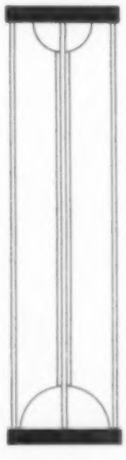

Fig. 10—Hainault Bridge. Rolled Steel Joist Stiffeners for Main Girders

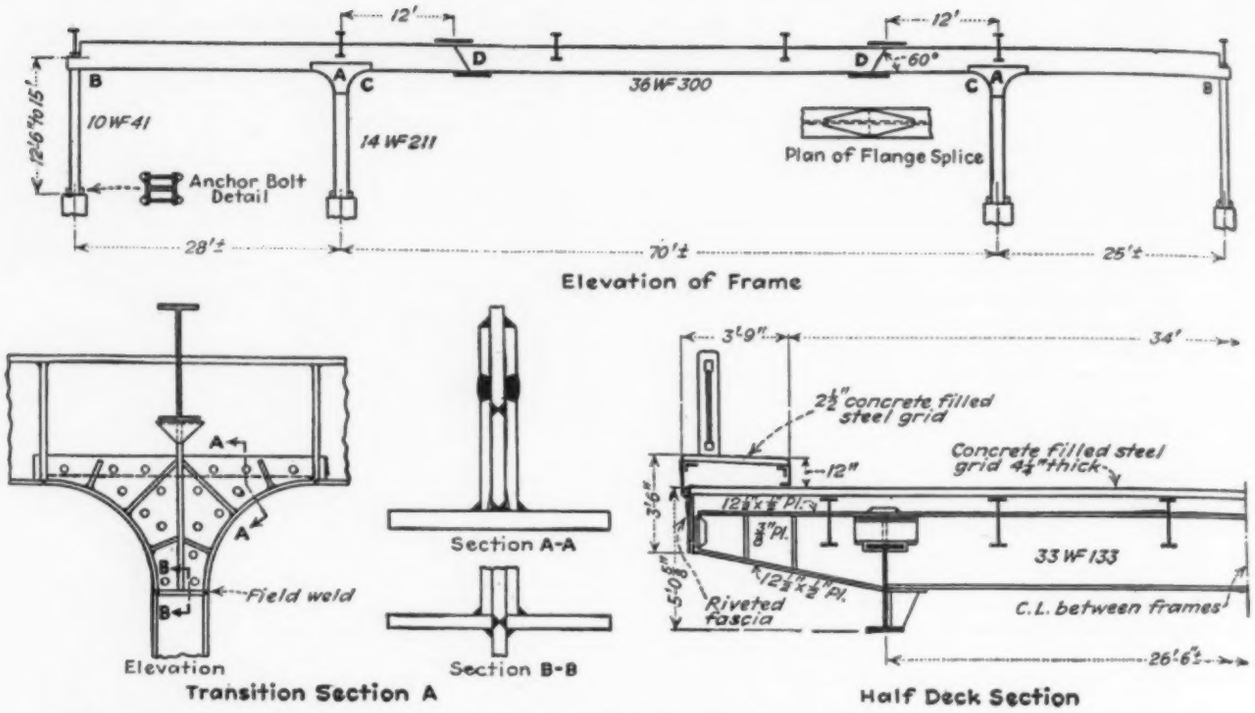

Fig. 11—Structural Details of the Two Welded Rigid Frame Bridges That Form Part of the Main Avenue Bridge Approach in Cleveland

inches thick. Steel joists were used as stiffeners, cut at top and bottom as shown in Fig. 10. It is claimed that the amount of work required in making and fitting this type of stiffeners compares favorably with that required in fitting flats or tees. The welding at right angles to the line of stress is reduced to a minimum.

The girders which were shop welded were positioned for all important welds. The engineers, before fabrication was started, prepared a chart giving an exact procedure to be followed in making all shop and field welds.

In this country and for new construction welding has been and is being used principally for the fabrication of auxiliary parts of bridges such as rockers and shoes, railings, expansion dams, floors, curbs, fascias, light poles, catch basins, troughs, downspouts, stairways, catwalks. On Cleveland's new Main Avenue Bridge, constructed under the supervision of County Engineer John O. McWilliams and County Bridge Engineer W. E. Blaser with the writer as Chief Design Engineer, more than 400,000 sq. ft. of welded floor construction, 3 miles of an all-welded railing assembly, 5 miles of welded curb and comparable quantities of each of the items noted above were used.

In addition to these auxiliary parts, two all-welded, three-span rigid-frame bridges were constructed. These were the first all-welded bridges to be built in the Cleveland area. The design and construction of these bridges have been discussed elsewhere (*Engineering News-Record*, July 18, 1940). A brief description follows:

The two bridges are similar, each having a total length of approximately 125 feet and a width of 40 feet 6 inches. Except for riveted fascias, used to conform with adjacent riveted structures, the two bridges are completely welded. The continuous welded frames are fabricated from standard wide-flange sections except for the transition sections *A* located at the tops of the interior columns as shown in Fig. 11. These sections *A* provide for full continuity between the girders and the interior columns and were formed by flame cutting out a section of the flange and adjacent web of the girder to a depth of 3 inches from the outside of the flange. Section *A* was then built up by shop welding as shown in Fig. 11. The three web plates were used to safely carry the high compression and shear stresses created in the inner flange and adjacent web of such sharply curved sections subjected to large bending moments. The two outside plates

Fig. 12—Transition Section. Welded Rigid Frame Bridge, Cleveland

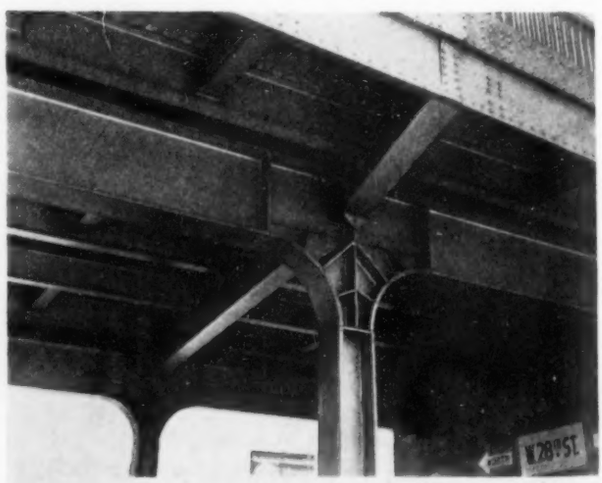

Fig. 13—Welded Rigid Frame Bridge, Cleveland

were also used to provide a very small but adequate amount of lateral flexibility to eliminate the possibility of a "brittle failure" due to biaxial or triaxial stresses caused by intersecting and overlapping welds.

The only field welds on the frames were made at *C* and *D*, Fig. 11. Figure 12 shows a view of one of the transition sections *A*. A completed bridge is shown in Fig. 13. The welded railing consists of a rectangular tube top rail 4 by 5 inches, a 4-inch square tube bottom rail and $2^1/_2$-inch-square tube spindles. The posts are 8 inches square tube fabricated from plates. The welded, tapered, square tube light standards which were designed for this project may also be seen in this figure.

More than a thousand welded bridges have been built during the past fifteen years, most of them during the past five years. Probably less than one per cent of these bridges have been constructed in North America. There have been a few serious failures and several minor ones. Unfortunately most of our progress comes as a result of our failures rather than because of our successes. As a consequence all new major developments must be accompanied by a few such failures. However, an overwhelming majority of these welded bridges are safely and economically performing the services for which they were constructed.

We have learned the importance of many factors which influence the proper design of a welded bridge. These include the following (see also Grover article, THE WELDING JOURNAL, September 1940):

1. The steel must be of assured weldability, with a relatively low carbon content similar to the now commonly used A. S. T. M. A-7 steel.
2. The pieces must be more carefully prepared than for riveted construction, in order to avoid large field welds required by inaccurate fit.
3. The various pieces must be assembled and the welds made in such an order that the locked-in stresses, which result from the cooling of welds which join pieces restrained against movement, will be controlled and held to minimum values.
4. On important welds, large electrodes requiring high heat and depositing heavy beads, should not be used, if conditions are such that serious locked-up stresses may result.
5. Welded assemblies should be kept as flexible as possible.
6. Avoid irregularities, sudden changes in sections, and all discontinuities.
7. If possible avoid the use of very thick plates requiring heavy welds.
8. Do not use unnecessary welds or welds heavier than those needed for service requirements. Reduce all welding and especially field welding to a minimum by using long pieces and shipping large assemblies.
9. Avoid overlapping and intersecting welds.
10. Provide complete and specific welding instructions to the shop and field forces.
11. Preheating can be used to advantage, especially in cold weather.

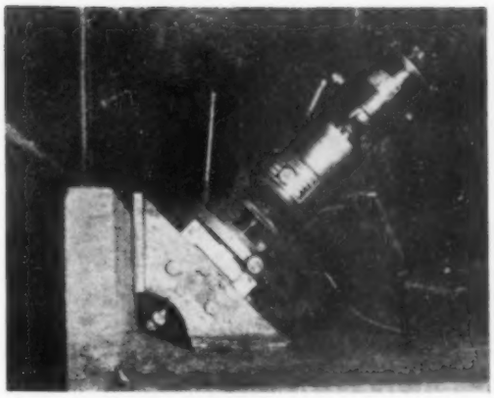

Fig. 14—Schmuckler Test

12. Do not use stiffeners on tension members. If splice plates are used, use tapered or elliptical splice plates with concave rather than convex welds.
13. Use well-trained welders and inspect welds carefully. In Europe X-ray inspection has been used on much bridge welding. The milling cutter designed by Schmuckler and shown in action in Fig. 14 has also been used extensively. This machine makes a cone-shaped hole in the weld metal which can then be etched with a 20 per cent nitric acid solution or similar etching agent, and examined for defects. The test can be made easily. It shows up defects such as slag inclusions or gas holes in the weld deposit, indicates the depth of penetration in the base metal and whether fusion is proper or incomplete. This test is not expensive and in conjunction with rigid qualification tests seems suitable for field inspection.

Now that we have reviewed some of the welded bridges which have been successfully (and unsuccessfully) constructed and have noted some of the factors which may in part determine whether your welded bridge will be a failure or a success, let us return to the question raised at the beginning of this discussion. The fabrication by welding of some bridge structures seems fully justified from every point of view. However, we must all—engineers, fabricators, erectors, suppliers of equipment and materials—first, inform ourselves thoroughly and expertly as to the technical, economical and practical problems which must be solved if welded fabrication is to be generally accepted for bridge structures; second, cooperate to secure adequate solution of these problems and so make impossible any haphazard development which might delay real progress. The writer is convinced that those of us who are engineers have not done our full work and met our entire obligation until we do possess this knowledge and until we do actively attack and solve these problems. We must each play our part. If we do, the time may not be far distant when your answer, and that of many engineers, to the question which was raised at the beginning of this discussion will be in the affirmative.

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(*Continued on page 323*)

Design of Logging Trailer for Welded Construction*

THE accompanying design relates to vehicle construction, and has reference more particularly to the construction of trailing vehicles although it is not the intention that the design be limited to that character of vehicles.

Explanatory to the design, it will here be stated that it is a general practice in the construction of log trailers and vehicles of similar nature, to incorporate in the frame structure of the trailer various storage tanks for compressed air, vacuum and water to be utilized in the cooling of brakes and for other purposes. Such tanks not only add considerably to the weight of the unit, but also are objectionable from the standpoint of occupying space which could be advantageously put to other uses.

In view of the above, it has been an object of this design to provide a vehicle frame of tubular members which may be utilized as storage tanks, thus to eliminate the necessity of using tanks as accessories, and providing also that the space which is ordinarily occupied by storage tanks can be used for other needed purposes.

It is another object of this design to provide a trailer especially for the tractor-trailer type of truck as now being used quite extensively for log hauling; the novelty of the construction residing in the use of tubular members, so assembled and welded as to provide maximum strength and minimum weight.

It is a further object of this design to seal the tubular members in air- and water-tight joints and to so equip them that they may selectively be used for water, air or vacuum.

* Data and illustrations from a study submitted to the James F. Lincoln Arc Welding Foundation by W. J. Jarvis, superintendent and engineer, Isaacson Iron Works, Portland, Oregon, in a recent program. In its current $200,000 Industrial Progress Awards Program, which closes June 1, 1942, the Foundation is offering 458 awards from $100 to $13,700, for reports of advances and improvements made by application of arc welding in design, manufacture, fabrication, construction and maintenance.

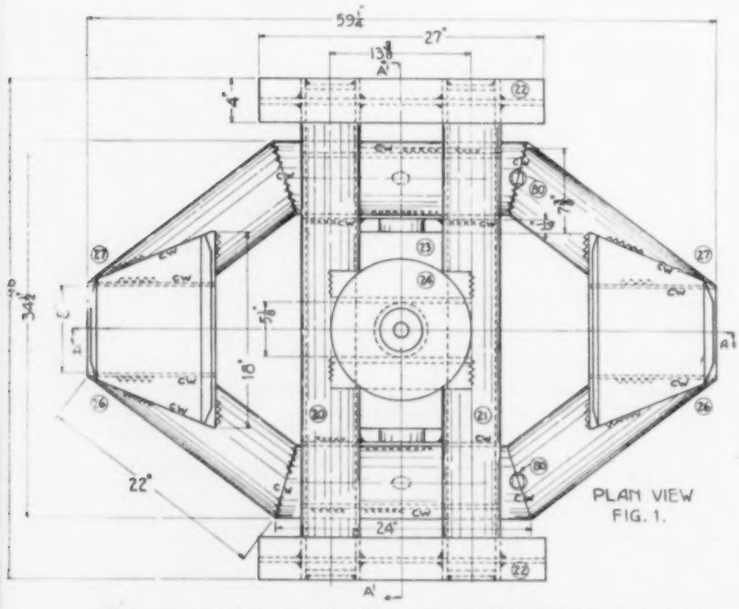
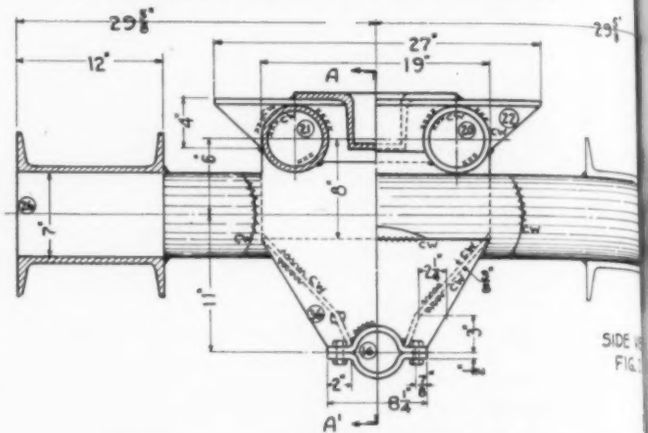


Fig. 1—Partial Top, or Plan View, of a Trailer Having a Frame Structure Embodying the Present Design

Fig. 2—Shows Side View and Detail of Frame Assembly



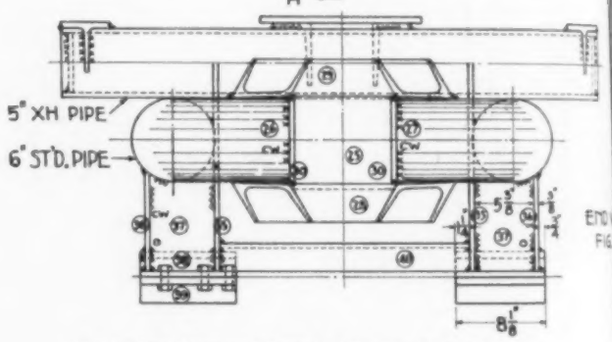


Fig. 3—End View and Detail of Frame Assembly

In accomplishing the various objects of the design, I have provided details of construction, which are illustrated in the accompanying drawings:

Figure 1 is a partial top, or plan view of a trailer having a frame structure embodying the present design.

Figure 2 shows side view and detail of frame assembly.

Figure 3 shows end view and detail of frame assembly.

Photos (Figs. 4, 5 and 6), show, respectively, the arc-welded tubular frame in action and various views of construction.

Briefly described, the chassis of the trailer unit embodying the present design comprises four sets of ground wheels mounted on the opposite ends of two cross axles, which, through the medium of suitable springs, are mounted in tandem on the opposite ends of a centrally located cross shaft. Upon this cross shaft is supported the tubular structures which form a reach guide and bunk mounting base.

The bunk mounting base is comprised of two parallel and co-extensive transverse tubes that are fixed upon and centrally across the reach guide frame. This latter frame is composed of short lengths of tubing, with those lengths at opposite sides of the longitudinal center welded together, end to end, and the opposite side portions thus

formed are jointed with their corresponding ends in spaced relation, thus to provide for the reception between them of a reach beam. A mounting seat for a log bunk is provided centrally of the structure which is thus formed by the transverse and longitudinally extended tubes, and the bunk is symmetrically located with respect to the four sets of ground wheels.

The feature of the design resides in the use of the tubular members and in the sealing of the tubular sections so as to form storage tanks for air and fluids.

In the trailer unit the bunk mounting base structure comprises the two parallel co-extensive tubes, *20* and *21*, fixed in space relation and centrally upon the reach guide structure, which, in plan view as best noted by reference to Fig. 1, is somewhat of hexagonal form and is composed of opposite side sections, *26* and *27*, co-extensive in length and joined in spaced relation across their ends for the reception between them of a reach beam.

Disposed centrally of and transversely beneath the above-mentioned structure is a trunnion shaft (see *16*, Fig. 2). This shaft is mounted in bearings supported by brackets, *36*, that are welded to and extend downwardly from the tubular members, *26* and *27*.

Fig. 4—All-Welded Tubular Dual Purpose Logging Trailer Frame

Referring again to the base structure for the log bunk, the two tubes, *20* and *21*, are joined rigidly together across their ends by short lengths of T-beams, *22*. These beams are disposed with the flat base across the beams, as seen in Fig. 2, to form supporting slides for the log bunk which would be centrally pivoted in a flanged socket member, *24*, or seat that is fixed in a plate, *23;* which, in turn, is fixed upon the tubes centrally of the structure.

The opposite ends of the tubes, *20* and *21* are closed and sealed by welding in circular end plates.

Disposed beneath the transverse tubes, *20* and *21*, and at opposite sides of the reach beam, *25*, whereby the trailer is to be connected to the power unit, is the reach guide structure, which comprises the two longitudinally extending tubular portions, *26* and *27*, converging at their ends angularly toward the longitudinal center. These converging portions are designated in Fig. 1 by *26* and *27*.

The short lengths of tubing used in making the two tubular half sections (see Fig. 3) are welded. In this case, in air-tight joints the sections are sealed at their outer ends by plates, *30*, and the sealed ends are spaced apart to accommodate the reach beam, *25*. At their forward and rearward ends, the longitudinal sections, *26* and *27*, are rigidly united by channel-iron plates, *28* and *29*, which, respectively, overlie the tubes so as to serve with the latter as guideways for the reach beam.

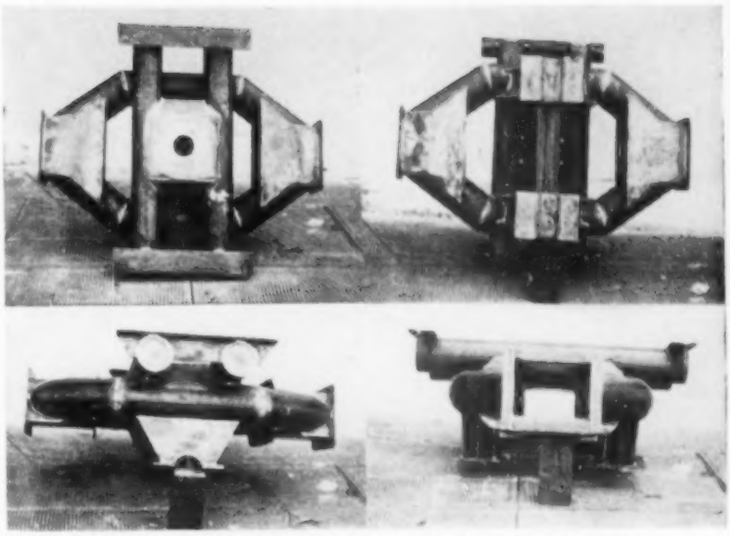


Fig. 5—Four Views of Electric-Welded Tubular Dual Purpose Logging Trailer Frame. (Upper Left) Top View. (Upper Right) Bottom View. (Lower Left) Side View. (Lower Right) End View

Disposed in vertical planes along the inside edges of the two tubular sections, *26* and *27*, and extending both above and below these tubes are the web plates, *35*. Above the said tubes, *26* and *27*, these web plates extend approximately to the center of the transverse tubes, *20* and *21* as seen in Fig. 3 and are so formed or notched as to fit around them and are welded or otherwise fixed thereto. Below the longitudinal tubes, *26* and *27*, the web plates extend downwardly to some extent and are welded to the bearings, which mount the shaft, *16;* these latter bearings comprising upper and lower sections designated at *38* and *39*. The upper section, *38*, at each side being welded to the plates, *35* and *36*, and lower section, *39* is bolted to the upper section, *38*, thereby forming a fixed mounting for the trunnion shaft, *16*. An angle iron brace, *40*, is fixed horizontally between the lower edge portions of the vertical plates, *35*, to strengthen the trunnion mounting.

Plates, *37*, as noted in Fig. 3 are welded between the plates, *35* and *36*, to co-act with the pipes, *26* and *27*, and top sections, *38*, of the shaft bearings to form closed compartments as noted at *40* in Fig. 3. These compartments have openings into their respective tubes, *26* and *27*, as seen at *26* and *27*.

The chambers, or tanks, provided by the transverse tubes, *20* and *21*, are connected together by an air pipe.

The longitudinal tanks, *26* and *27*, equipped to be filled with water by removal of the plugs, *80*, have valves opening into the compartments or tanks. From these valves, pipe or hose lines at each side of the vehicle connect with spray nozzles on both the front and rear brake drums which are arranged to spray water on the

Fig. 6—Two Views of Trunnion Bracket Before Welding to Frame

outside of the brake drums. These spray nozzles are fixed to a stationary flange that is a part of the axle and remain in a fixed position with reference to the trailer while the wheel and brake drum revolve.

Assuming the device to be so constructed, the use thereof is as follows:

Removal of the caps or plugs, *80*, from the tanks, *26* and *27*, provides that these tanks may be filled with water. Before the vehicle starts down any long, descending roadways, such as encountered in mountainous timber country, the valves are opened manually by the truck operator and the water feeds to the spray nozzles by gravity. When the brakes are in constant use, as on such long descents, the brake drums would otherwise become overheated, sometimes to such an extent that the brake lining ignites, rendering the brakes useless in a very short time. By spraying water slowly upon the brake drums, they are kept cool, rendering the brakes more efficient and eliminating the possibility of brake failure.

Total Savings to Trailer and Logging Industry Using This Design: 35% saving on labor over cost of manufacturing previous design; 10% increase in payload under present highway laws; 8% saving in license fees (based on 0.80 cwt. Oregon Law).

Renewing Crusher Life by Bronze-Welding

By H. A. Yost*

BECAUSE of the unusual nature of the job, the recent reclamation of a 5-ton, cast-iron, rock-crusher anvil by bronze welding and bronze surfacing effectively demonstrates the extreme flexibility and adaptability of the oxyacetylene process. As shown in the sketch, this casting is about 63 in. wide and, when installed in the rock crusher, is supported by a 9-in. diameter shaft which passes through one end.

Damage and Preparation

Here are located three bearings, one at each end of the shaftway, measuring 9 in. in diameter by 7 in. long and the third, midway between these two, measuring 9 in. in diameter by 5 in. long. Lengthy service had worn all three bearings from $^1/_2$ in. to as much as $^3/_4$ in. oversize. In addition, two cracks had developed at the outer edges of each of the outside bearings. Each of these cracks was about $2^1/_2$ in. deep and extended through the bearing boss and into the body of the casting for a total length of approximately 6 in.

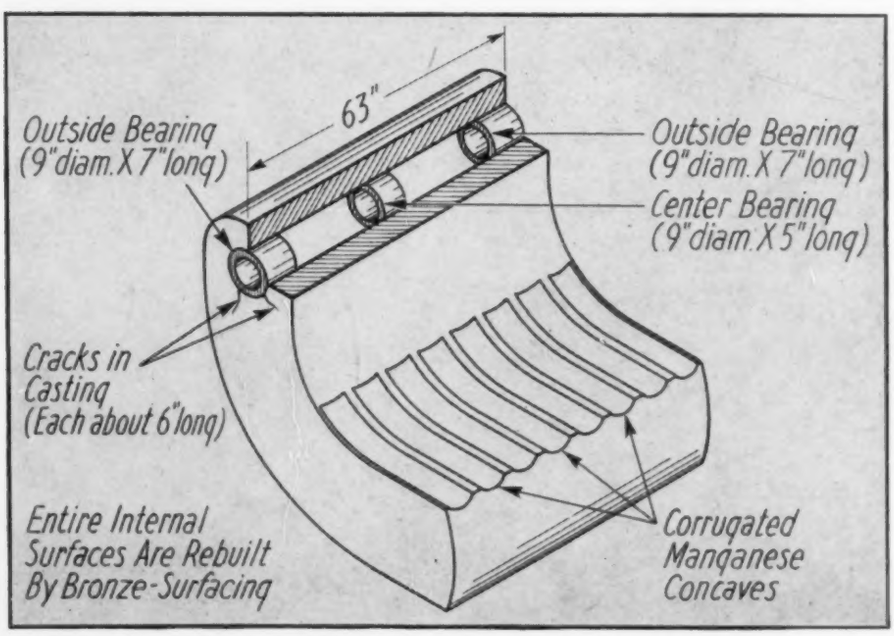
Before welding, it was first necessary to prepare the cracks by chipping. Each was carefully veed down to the full depth of the fracture to insure thorough penetration and provide a clean surface for deposit of the bronze weld metal. Worn surfaces inside the bearings were clean and required no preparation before rebuilding. After the chipping operation had been completed, the casting was set up in a temporary firebrick furnace and preheated to a dull red by means of gas burners.

Order of Welding

Because the only access to the center bearing was through one of the worn outside bearings, it was necessary to use an extra-long welding head with a blowpipe in order to reach the worn surfaces located from 29 to 34 in. inside the casting. The center bearing was built up first, using $^1/_4$ in. diameter bronze rod and Brazo flux. Due to the heat and tediousness of working in such a confined space, two operators alternately relieved each other until this portion of the work was completed. Then the veed cracks extending from the outside bearings were bronze welded.

By this time the day was over, so the casting was covered over with asbestos paper and left overnight with the gas burners on to maintain the preheat temperature. On the following day the two outside bearings were rebuilt to size, again using $^1/_4$-in. bronze rod and Brazo flux. All this time the casting had been kept at a dull red heat but, when the third and final bearing was completed, the gas burners were turned off and the furnace was covered over again with the asbestos paper. The casting was then allowed to cool slowly before machining the bearings to proper size.

Total welding time was about 17 hr., of which 9 hr. were used in rebuilding the center bearing and bronze welding the four cracks. The two outside bearings were rebuilt in 8 hr. on the second day. The entire job required 80 lb. of $^1/_4$-in. bronze rod and approximately 920 cu. ft. each of oxygen and acetylene.



The Worn Rock-Crusher Anvil Was Reclaimed by Rebuilding the Bearings and Bronze Welding the Cracks Shown in This Sketch

* The Linde Air Products Co., Kansas City, Mo.

Modern Methods of "Tooling Up" Speed National Defense Production

By Ed C. Powers*

MODERN methods of "tooling up" for National Defense production can save 31% overtime formerly required, also reduce cost and weight of jigs and fixtures by 32% and 17%, respectively.

The data upon which these figures are based were submitted in a report by officials of a large company now actively engaged in production of mobile field military equipment. The purpose of the report was to show the advantages of modern arc welding in the essential operation of producing jigs, fixtures, etc.

"Tooling up" for production required a total of 112 special jigs, dies, fixtures, etc., which were made by arc welding at an actual cost of $8476.24 and in a total of 3696 man-hours.

Before adopting modern welding for these tools, a careful estimate was made to show the cost and time required. This estimate included the patterns and their machining, plus the cost of materials. On this basis the cost of tools and fixtures by the former method was $12,467.84 and the man-hours 5264.

Figures giving comparative cost, fabricating time and weight for the new welded construction and the former method, covering 8 typical examples of jigs and fixtures in this plant are given in the following tables, also shown in the accompanying illustrations.

As shown in the table, the 8 welded jigs and fixtures were made at cost savings of $318.97, which is only slightly less than the cost for patterns alone for the former method ($403.50). Thus, practically the entire cost of patterns was saved.

* Assistant Secretary, The James F. Lincoln Arc Welding Foundation, Cleveland, Ohio.

Savings with Arc Welding

Cost:	
For former construction	$1001.93
For welded construction	682.96
Cost Saved	$ 318.97
% Savings	32%
Fabricating time:	
For former construction	436 Hours
For welded construction	301 Hours
Time saved	135 Hours
% savings	31%
Weight:	
For former construction	9647 Lb.
For welded construction	8012 Lb.
Weight saved	1635 Lb.
% savings	17%

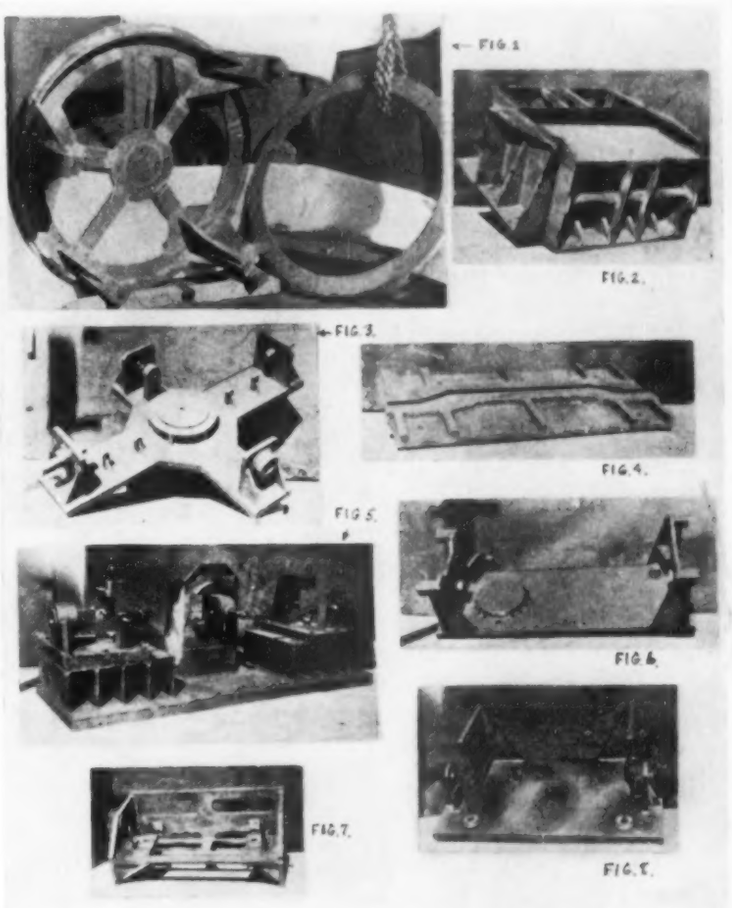


Fig. 1—Arc-Welded Milling Fixture for Circular Truck Part. Fig. 2—Movable and Stationary Die of Arc-Welded Construction. Fig. 3—Arc-Welded Drill Jig for Front Axle. Fig. 4—Die of Arc-Welded Construction for Front Steering Rod. Fig. 5—Arc-Welded Boring Fixture for Front Axle. Fig. 6—Axle Drilling Fixture of All Welded Construction. Fig. 7—Arc-Welded Drill Jig for Frame Die. Fig. 8—Arc-Welded Drill Jig for Center Plate of Truck Frame

Savings in Time and Cost on Jigs and Fixtures by Welded Construction

	Arc-Welded Construction			Former Construction			
Item	Cost	Time Hrs.	Weight Lb.	Cost	Time Hrs.	Weight Lb.	Pattern Cost
Milling fixture for truck (Fig. 1)	$ 92.71	50	1505	$171.12	64	1808	$ 73.50
Movable and stationary die (Fig. 2)	103.47	36	1634	165.16	57	1980	59.50
Drill jig for front axle (Fig. 3)	73.98	36	792	102.43	43	950	40.50
Die for front steering rod (Fig. 4)	67.66	26	228	92.16	58	273	58.50
Boring fixture for front axle (Fig. 5)	163.92	63	2068	227.62	95	2512	74.00
Drilling fixture for axle (Fig. 6)	80.25	33	848	90.76	34	1000	32.00
Drill jig for frame tie (Fig. 7)	41.59	25	362	65.12	39	434	32.50
Drill jig for center plate (Fig. 8)	59.38	32	575	87.56	46	690	33.00
Totals	$682.96	301	8012	$1001.93	436	9647	$403.50

Machine Flame Cutting in Preparation for Welding*

By W. Roy Widdoes†

THIS paper describes the part of machine flame cutting in the preparation of material for welding. It avoids technical discussion of cutting tools, recommendations for speeds, pressures, tolerances or tip sizes, for they are governed in the main by the type of work and the human factor. Types of equipment necessary to produce the parts and the different operations of the cutting machines are described, such as shape cutting, circular cutting, bevel cutting, multiple torch cutting and straight line machine cutting. Covered also are the making of templates for shape cutting machines, and checking of the pieces for dimensions, gage, surface and flatness. The author discusses the gages and quantities of steel necessary for an adequate inventory for prompt production and shipment.

Nearly every fabricator's first line of defense is prompt procurement of his material. More especially now, the speed with which parts can be cut from steel plate is an important contribution of machine flame cutting. In order to furnish material promptly, it is necessary to maintain a large inventory of plates, including many different qualities, various gages, and especially extremely wide plates.

Design

Freedom in design is greater today because flame cutting makes it possible to produce almost any size and shape from rolled steel plate. In most cases we are furnished with the details of the desired parts. However, in cases of replacement of failed parts, it is possible to furnish the desired part from the broken section, which we have done in many instances.

* Presented at Annual Meeting, A. W. S., Cleveland, Ohio, Oct. 21 to 25, 1940.

† General Manager, By-Products Steel Corporation, Division of Lukens Steel Co , Coatesville, Pa.

Templates

After receiving the prints, the template men decide the type of template, whether it is to be drawn on paper, scribed on aluminum or steel plate, cut from steel plate or to be produced with aluminum track which is mounted on a steel plate.

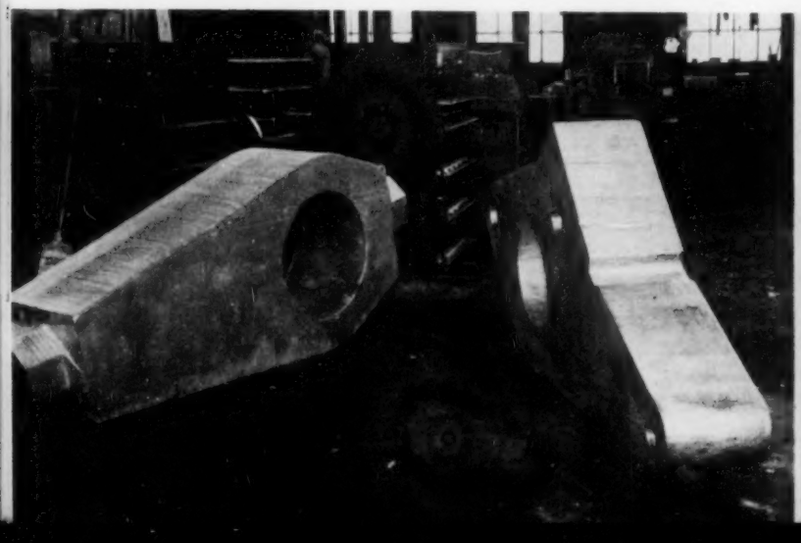
Allowance is made for the cutting kerf and also the inevitable contraction which occurs when the piece cools. The first piece cut is also checked.

Cutting Equipment

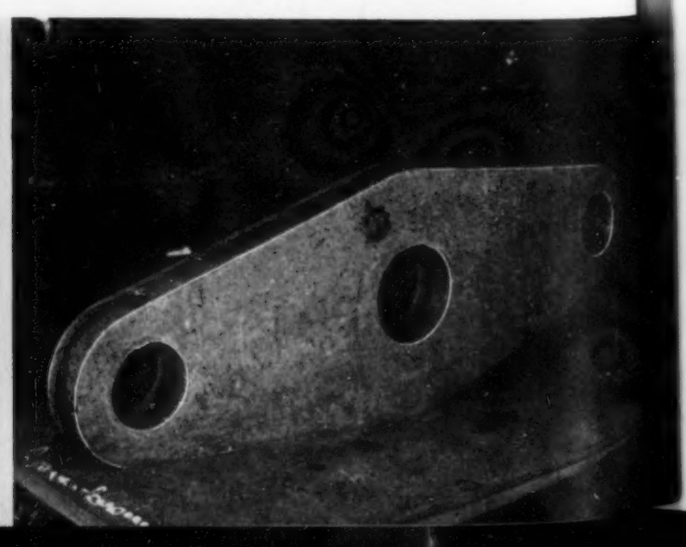
We have three travographs, two of which have cutting range in width of 144 inches and one 120 inches in width. On the 144-inch machine, we are able to cut about 80 feet in length. We also have six pantographs with a cutting range of 50 inches in width and 20 feet in length. These units are commonly known as shape-cutting machines and are probably the most exact in the flame-cutting process. They are equipped with different type tracing units, one of which is the manual. In this type it is necessary for the operator to guide the unit over the lines on the paper template or on the steel or aluminum plate. The paper template is commonly used when a single pattern or small quantities are required. This is an economical and rapid method of producing templates. It is very important, however, to use a very good grade of paper, because the best is very susceptible to atmospheric conditions. Paper templates will shrink and should always be checked carefully before use.

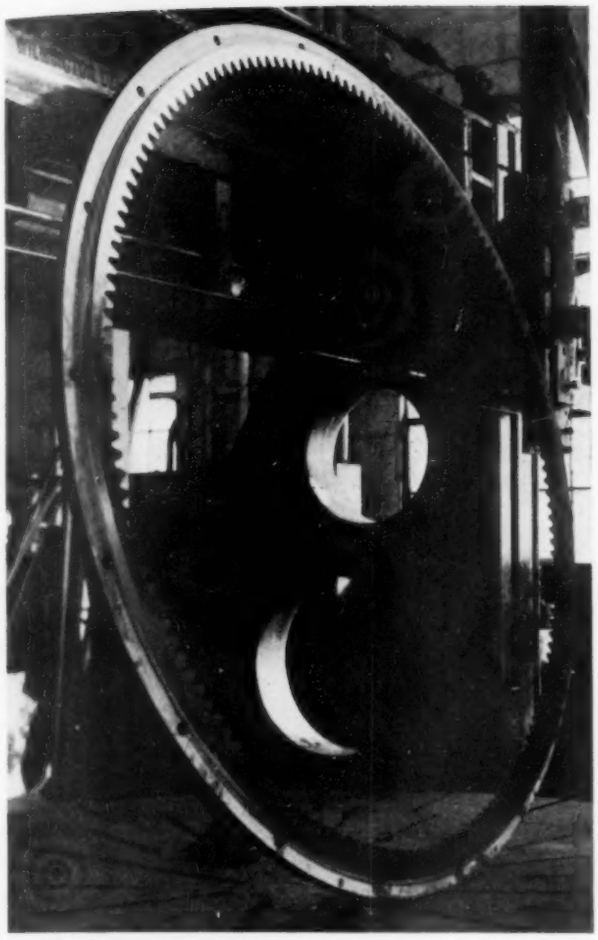
The accuracy of the pieces produced from the manual tracing unit is almost entirely the responsibility of the operator, providing, of course, the templates were made correctly, as he can only produce the section over which

High-Pressure Cylinder Yoke 12 In. and 20 In. Thick for Use in the Construction of a Hydraulic Metal Baler



Flame-Cut Plate 79 1/2 In. Long, 27 In. Wide, 5 1/4 In. Thick, with a Diameter Center Hole and Two 8 In. Diameter End Holes for Use in the Construction of a Diesel Engine





Steel Bearing Gear Flame-Cut. This Gear Measures 119 In. O. D. X 106 1/4 In. I. D. X 3 In. Thick, and Has 162 Teeth 1 1/2 In. Deep. The Gear Was Used Without Any Machine Work on the Teeth

he operates his tracing wheel. Another type of template is the track template which is produced by scribing on steel plate or board, the contour of the shape desired, after which the aluminum track is formed to the shape drawn and then riveted onto the plate. The tracing unit is equipped with two knurled wheels which fit over the track and follow it. The pattern is cut accordingly.

The third type is the permanent steel template which is produced by flame cutting from steel plate. On this template a magnetic cam is used and the allowance is governed by the diameter of the cam. The steel template is mounted on pins, as the cam on the tracing unit is directly over the template and it must be elevated sufficiently from the tracing table to permit the cam to follow the contours. These templates can be made for internal or external cutting of the pieces. The steel templates and the track templates are the most desirable as the operator is practically free to observe his cutting, and it is only necessary for him to start and stop his tracing unit. The aluminum track template and the steel plate template are a distinct advantage in multiple flame cutting, whether it be two, three or four torches.

Since industrial requirements are so diversified as to sizes and thicknesses, it is necessary to furnish parts from 1/4 inch in thickness up, and the heaviest gage we have furnished is 27 inches in thickness.

In cutting parts internally up to approximately six inches in thickness, the cut is generally started with the machine torch. With thickness greater than six inches the general procedure is to start the cut by lancing a hole. The hole is made with a length of 1/4-inch pipe attached to a separate oxygen line and generally the area at the start is heated with a hand torch. After blowing the hole it is good practice to make a trial cut, for a twofold purpose first, to determine the straightness of the cut and, second, the smoothness of the cutting, which will enable the operator to make the adjustments before he actually cuts his pattern. While there are numerous tables issued on speeds and pressures, we feel the human element must be considered, and also the quality of the steel.

There are many patterns required which must be formed by pressing, bending or rolling which afterward must be flame cut either internally or externally. The shape-cutting machine is valuable in this type of work. In some cases jigs are required to hold the formed parts and these jigs are generally flame cut.

After cutting the various shapes, the next operation is the removal of the slag, after which the parts go to the checking department. This is an important operation and requires more time than the cutting. The checkers or layout men must be able to read blue-prints, as they must inspect for dimensions, surface, gage, flatness, proper marking and quality of cutting. They must take into consideration the tolerances and also the application of the part if they have an assembly drawing. This is quite an advantage, in addition to the detailed drawing. After the different inspections are made, the checkers proceed to lay out the bevels and these are of numerous types, single, double, irregular, intermittent, shallow and deep. Bevels can be produced more satisfactorily with the hand torch, with the exception of the long straight bevel. Again the human element controls the accuracy of the bevel and men should be especially trained in this type of operation. This type of beveling is quite a saving as it eliminates expensive machining. It is necessary to grind some of the edges after beveling, especially where the part required is to be welded by the Union Melt Process. The parts should again be checked after beveling, and as previously stated the checking is a very important operation, requiring experienced men. They must also see that the pieces are correctly marked for identification purposes. There are also pieces required which must be fitted up in the flame-cutting department, especially in wheels where a web fits into a hub and a band fits around the web. The checker must check the band and have the web and hub cut to fit. In some instances a grind fit is required.

There is another type of shape-cutting machine known as the camograph. This machine uses a steel template and is employed primarily for cutting circles of standard sizes in small quantities, as it will produce only one at a time.

There are also circular pieces or heads which are formed with a flange. It is necessary in many instances to trim and bevel these pieces. One method which we feel is the most practical is to place the head on a revolving table similar to a boring mill and have the torch stationary. The cutting jet is projected to the angle desired, to produce either internal or external bevels or both with a slight adjustment. Then again there are other formed parts with irregular planes where it is necessary to bevel or trim to the plane. In this work, it is necessary to use a machine mounted on three wheels, which is operated by hand. The machine is placed on the inside of the part and in this manner you can produce the height of bevel required in relation to the plane of the part.

Radiograph or straight line cutting produces numerous pieces for the welding industry. This machine is essentially a motivated cutting torch. The smoothness of the

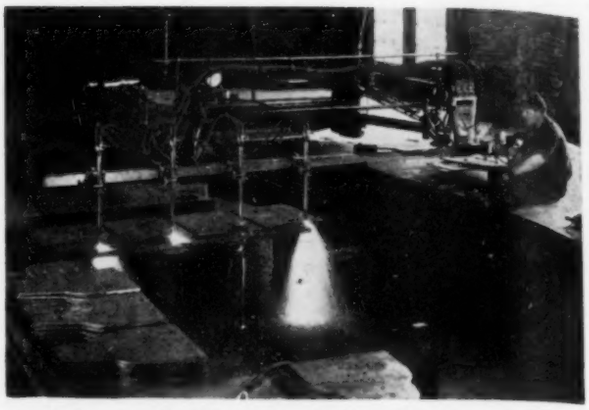
cutting surfaces depends to a large extent on the operation of the propelling device. A rail or track is used by the operator. The track is lined up to the plate layout and the accuracy of the cut is governed by the allowance in the layout. It is practical, in cutting long plates, for the operator to run two machines. The machines are also used to cut circles, which are produced with the machine operating directly on the surface of the plate and the use of a radius rod fastened to the machine which is centered geometrically. Bevels are also required on square, rectangular or circular flat plates, which can be produced in the same manner except with the adjustment of the torch to the degree of bevel desired.

In addition to inspection previously mentioned, it is necessary today to magnaflux numerous parts. We have four stations for this operation, and this inspection is being made daily.

After the parts have been produced it is necessary in numerous instances to flatten them and this is the final operation. However, some parts must be annealed, and flattened after annealing.

The numerous operations covered are all being performed daily in our Company.

We have presses, press brakes, bending rolls, annealing furnaces, flattening presses and with the many flame-cutting machines and other cutting equipment, which we consider actually necessary to furnish machine flame cut parts for the welding industry and finally it is most important to carry a large stock of plates or have them accessible. In this, we are fortunate in being a division of Lukens Steel Company, with our plant adjacent to the five Lukens plate mills.



One of Three Similar Flame-Cut Machines in Use at By-Products Steel Corporation. This Machine Permits the Cutting of Plates 10 Ft. 0 In. Wide X 26 Ft. 0 In. Long. The Machine Is Shown with Four Torches Cutting, Operating on Its Magnetic Tracer

Hard Facing Steel Equipment*

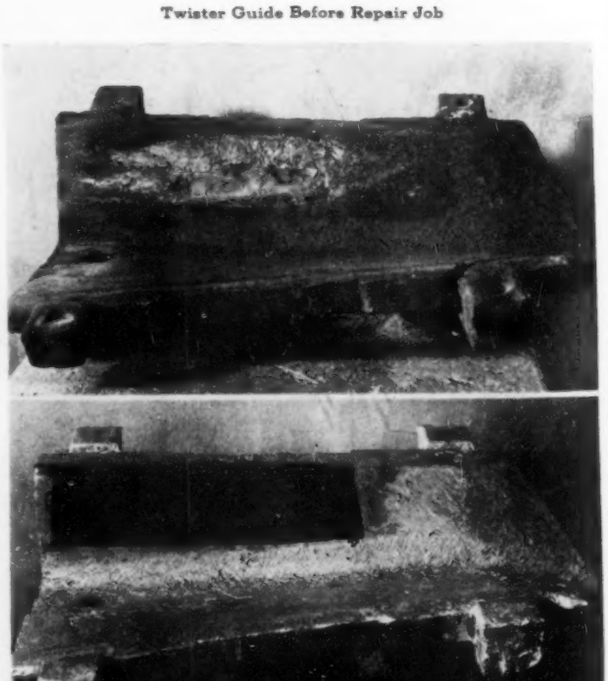
By Frank L. Gray†

THE oxyacetylene welding blowpipe and the arc welder have become indispensable maintenance tools in the operation of steel plant equipment. In these days of high operating costs and diminishing profits, it is paramount that the equipment be maintained at its maximum operating efficiency. A worn part which must be replaced and which causes a delay during the period of operation is a direct financial loss not only to the company but to the individuals who make up the operating personnel. To this end, it is the ambition of those responsible for maintenance to perfect the fast wearing parts to a point where the equipment might be kept in operating condition during the schedule of the mill, reserving the down maintenance turn for the replacement of parts which will not last through another scheduled run.

Where hardened steel applications are not feasible, it is often possible to build up with a rod similar to the parent metal, and finish off with a rod that will be wear-resisting. Where wear is limited to shallow dimensions, it sometimes becomes necessary to cut away the base stock before applying the hardened face material, in order to provide sufficient depth or proper backing for satisfactory results.

Spindles, or the connecting link for the transmission of power from the pinions to the rolls, are connected to the roll and pinion wobblers by means of loosely fitted coupling boxes. These spindles and in some cases the coupling boxes, are designed as the weakest part in the system

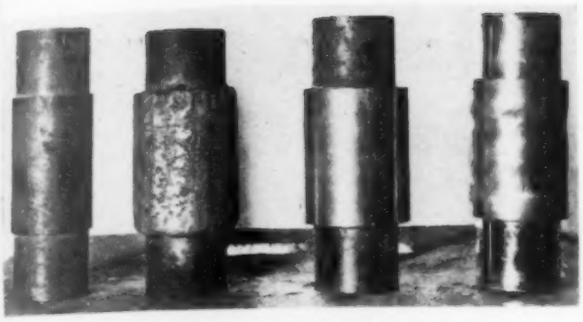
Twister Guide Before Repair Job



Twister Guide After Repair Job

*Presented at the Annual Meeting, A. W. S., Cleveland, Ohio, Oct. 21 to 25, 1940.

†Maintenance Department, Carnegie-Illinois Steel Corporation, Gary Works, Gary, Indiana.



Roller Guide in Several Stages of Preparation

of power transmission, to give way upon stoppage or blocking of the mill in order to save the more expensive equipment. The operation is reflected in the wearing of the cast-steel face of the wobbler and spindle. To minimize this wear the faces are built up with a dust-coated, medium carbon electrode and finished for the last one-half inch with a wear-resisting rod. High carbon, low carbon-high manganese, or carbon–nickel electrodes are used. On large pinion wobblers where the wear has been extremely severe, a section of rolled plate is used as a filler to reduce the amount of deposited metal. The section is so placed to form two "J" welds. The hard-facing procedure with the wear-resisting rod is followed as before.

This type of maintenance repair has resulted in three to five times longer average life of the wearing surface. Eight times the service life has been reported in some cases.

ROLLER GUIDES

In the reduction of a 4 x 4 inch billet to an area of 2 x 2 inches, the bar is passed through a series of diamond passes arranged in line. Between each pass the bar is turned 90° by a twister guide. To prevent the action of this guide turning the bar before it has completed its travel through the pass, a pair of roller guides on the leaving side of the mill is used. These guides are under extreme pressure and subject to the rolling temperature of the bar.

The finished roller is $4^1/_2$ inches long by 4 inches in diameter with $2^7/_8$-inch diameter necks 3 inches long. The low carbon roller is prepared by machining $^1/_4$ inch undersize. A jig, locally made, with adjustable, center-hole, roll supports, is used for the welding operation, and is covered to form a preheating furnace. The roller is preheated to a cherry red by a coke-oven gas flame and maintained at that temperature throughout the welding operation. The surface is thoroughly cleaned during the first pass with the blowpipe, and three layers of cobalt-chromium-tungsten rod are deposited. The deposited metal is smoothed during the finishing pass so that the amount of grinding required will not be excessive. The roller is slow cooled in slacked calcium lime, and ground to dimension.

Rollers are repaired by cleaning and smoothing the surface with the blowpipe flame before the hard-facing rod is applied. The roller necks are repaired after being worn $^1/_{16}$ inch. A similar hard-facing rod is used but with a higher tungsten content to give better wear- and shock-resisting qualities.

During the operation of the rolling mill, these rollers are water cooled. The average life is two months for the hard-surfaced roller, and eight hours without this preparation.

TWISTER GUIDES

Twister guides are used on a 24-inch mill with an entering billet dimension of 8 x 8 inches. The hot steel causes these cast-steel guides to fire crack. The service life has been greatly increased and repairs have taken the place of replacements by the use of higher tungsten-cobalt-chromium material. A wear-resisting face $^1/_4$ inch in thickness over the bearing surface has resisted the abrasive action and heat of the hot billet. The average service life of three days has been increased to 45 days, and the part is being repaired where formerly it was scrapped.

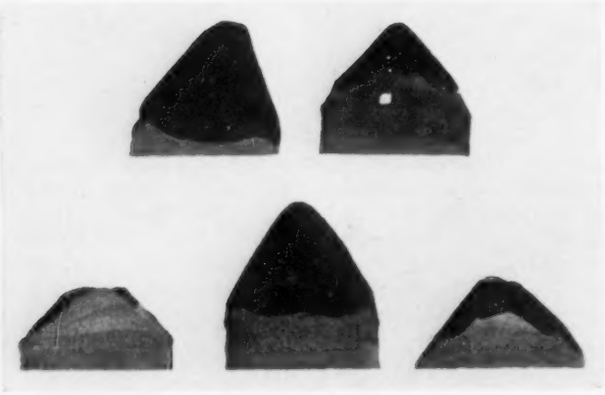
TONG BITS

The ingot as it comes from the stripper building weighs from three and a fraction tons up to the requirement of the section to be rolled. Good practice requires the charging of the ingot into the soaking pit immediately after stripping, to reduce the amount of heating necessary for rolling conditions. At this point in the operation the central portion of the ingot is still molten. A crane spans the soaking pits and, by the means of tongs, charges and removes the ingot. The tongs are equipped with $5^1/_2$-inch pointed bits which grip the sides of the ingot. Due to the extreme heat the points of the wear-resisting forged-steel bits are dulled and must be frequently replaced. A dull point may be the cause of dropping an ingot with damage to other equipment.

The stock used is a 0.90/1.05% carbon steel, forged from $1^1/_2$-inch rod with a $3^1/_4$-inch tapered shank, $1^1/_8$ inches long by $2^1/_{16}$-inch diameter head and a 45° tapered nose. In the preparation of the bit for hard-facing, several methods were tried and a test conducted in order to make available sufficient data to substantiate the preparation used. The hard-facing material employed was a cobalt-chromium-tungsten alloy.

In test No. 1, the tapered nose was ground off and a

Operation of Welding Roller Guides



Tong Bits After Use

concave hole, 1/8 inch deep at its center, was machined in the bit head. The nose was rebuilt to its original height with the facing metal and ground to the bit dimension. Seven and one-half ounces of metal were deposited in thirty minutes with a low welding temperature to assure a weld free of blow-holes. All pieces under test were thoroughly cleaned, preheated to a medium cherry with the blowpipe flame, resurfaced with a 2× carbonizing flame, and slow cooled in slacked calcium lime.

In rebuilding the entire nose, the bond of the two metals was at the maximum distance from the contact area with the hot ingot, and had transverse support by the parent metal. As the minimum forging temperature of the parent metal is 1100° F. and the hard-facing material 1832° F., this preparation was used to indicate the red hardness factor of the metal under the high operating temperatures.

In test No. 2 the bit was prepared by grinding off the nose with the exception of a protrusion 3/4 inch in height, rounded at the top, and 1/2 inch at its base from the greatest nose periphery dimension. Six ounces of hard-facing rod were deposited in twenty-five minutes under the same procedure as test No. 1. In this preparation the surface metal was reinforced to provide support. The parent metal was brought to a sweating temperature and the surface tinned with the facing material. This is the usual procedure in forming a bond with the cobalt-chromium-tungsten rod. The strength of the bond between the two metals under temperature changes and different expansion coefficients was studied by this test.

Test No. 3 was a duplication of test No. 1 with the exception of the welding procedure at the point of weld of the two metals. Instead of bringing the parent metal to a sweating heat, the hard-facing material was puddled with the base metal to form a fusion weld.

Test No. 4 was prepared by grinding off 5/32 inch of the nose surface to a horizontal distance of 7/8 inch, leaving a shoulder at a 45° angle to the working pressure. The piece was not ground to dimension which resulted in a finished nose similar in the general contour to the hard-facing application in test No. 2. The bonding procedure of test No. 3 was followed.

The ordinary carbon bit would lose its nose sharpness after the handling of 30 to 40 hot ingots. The hard-surfaced bits retained their sharpness throughout the test. Ingots handled were as follows:

Test No.	Above 2000° F.	Below 1500° F.	Total	Tongs Quenched
1	39	71	110	12
2	88	49	137	39
3	111	38	149	37
4	103	48	151	21

All tests developed cracks extending to the surface from interior gas or pin holes. Tests Nos. 2 and 3, in which the parent metal extended into the tip, separated at the bond.

It was concluded:

1. That the red hardness of the hard-facing material was sufficient to withstand the operating temperatures.
2. That the bond between the two metals cannot be inter-alloyed, but improvement is indicated to prevent separation by puddling.
3. That pin or gas holes must be excluded in depositing the facing material.
4. That the practice of cooling the tongs in water after handling from three to five ingots was a factor in the development of cracks.
5. That no benefit could be shown for a full hard metal nose.

With this information, test No. 5 was conducted. The preparation was similar to test No. 4 with the exception that the amount of deposited metal was held to the finished dimension. Ingots handled were as follows:

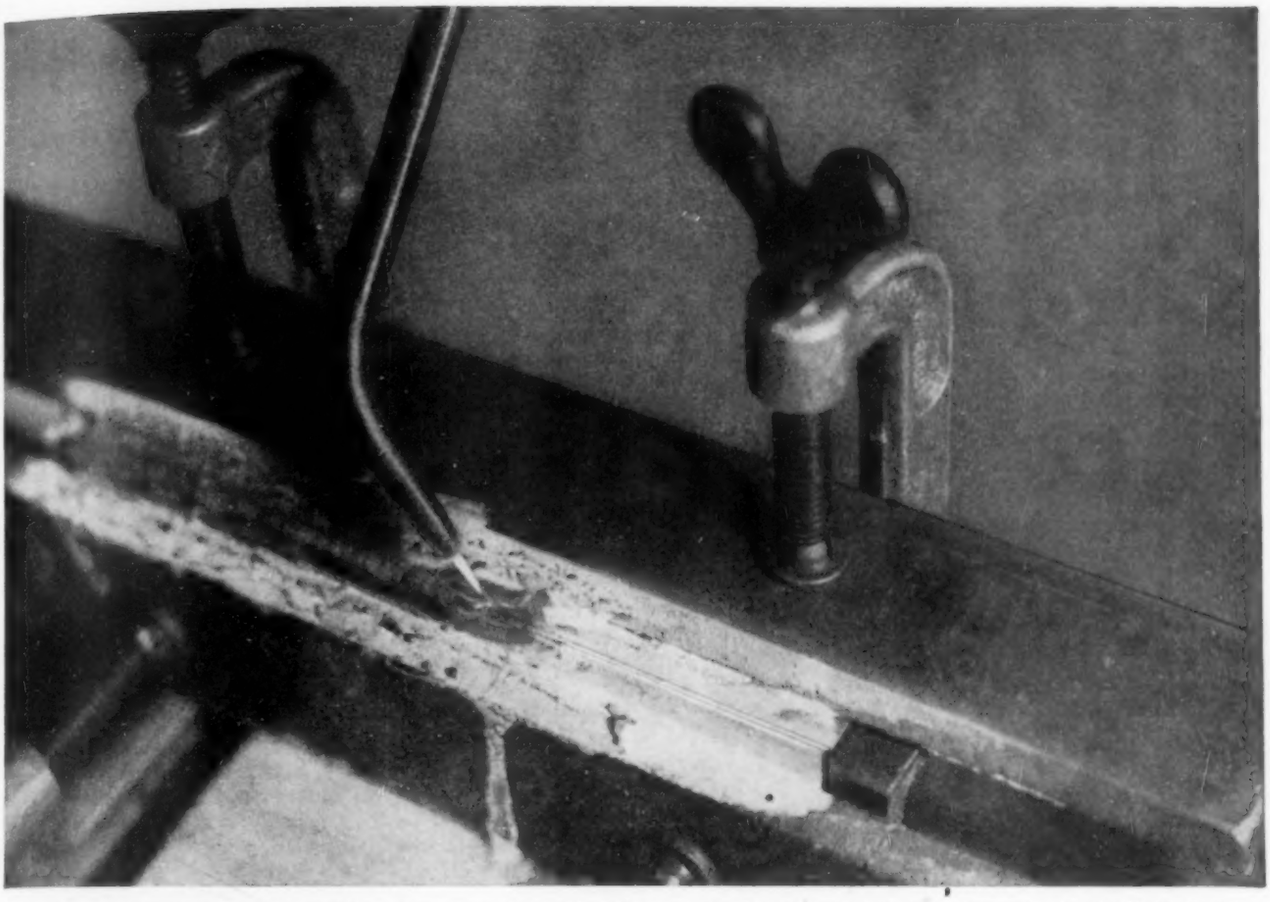
Test No. 5	Above 2000° F.	Below 1500° F.	Total	Tongs Quenched
a	69	171	240	14
b	127	107	234	22

On the basis of the above service life the monetary saving in material is very small. This, however, is not the consideration in the application of hard surfacing material on this particular operation. The fact that the soaking-pit crane is not delayed for the purpose of changing bits during the drawing of a heat will increase the production of the mill by at least one ingot for every delay previously reported.

The study of the hard-facing of tong bits has been made to eliminate ideas and procedures, in favor of the practice that insures satisfactory results. The investigation will be continued to include the bits used on the tongs of our heavier equipment.

CONCLUSION

In the practice of hard-facing fast-wearing parts of steel-mill equipment, the requirement will invariably necessitate the development of a welding procedure for each particular situation. This requires the close co-ordination of effort between the welding shop, the designing engineer, and the maintenance personnel.



Exceptional Resistance to Corrosion and Ease of Cleaning Admirably Adapt Stainless Steel for a Multitude of Uses in Food and Allied Industries. Simple Jigs Aid Fabrication by Welding

How to Weld 18–8 Stainless Steel

Part I: Joint Design, Metallurgy, Materials and Welding Procedures for Fabricating Light-Gage Sheet

By H. H. Moss†

A GREAT portion of the increasingly wide applications of stainless steel—particularly the 18–8 grade in the lighter gages—undoubtedly is found in the food products and allied industries. Two reasons for this are apparent: first, the exceptional resistance of stainless steel to many types of corrosion; and second, the ease with which this metal can be cleaned and kept spotless. Since these characteristics lead to product purity, so essential in the food and allied industries, machinery and equipment to serve this field are often fabricated from stainless steel. It is a fact, too, that welding is widely used in such fabrication, for welding adds the factors of strength, permanence, elimination of joint crevices and neat appearance to the finished metal product.

† Development Engineer, The Linde Air Products Co., Newark, N. J.

Joint Design

The successful welding of stainless steel, like the welding of other metals, requires a thorough understanding of other factors in addition to actual welding technique. Of particular importance is the subject of proper joint design for welding. Even the most perfect welding technique may fail to produce a satisfactory result if the joint design is faulty. A brief outline of basic principles and fundamentals of some of the types of joints most frequently used in welded fabrication of light-gage stainless steel and examples of how each is commonly used in actual practice will be helpful. Fundamental joint designs are relatively few in number.

The butt-type flange weld (sketches *A* in Fig. 1) is commonly used for joining two flat pieces of sheet lying in the same plane, for joining two sheets coming together to form a corner, and in rounded sections, such as the

longitudinal seam in the shell of a cylindrical tank or the girth seam between the sides and dished bottom of a cylindrical vessel. The edges are prepared for welding by turning up a flange, the upstanding portion of which should extend above the upper surface of the sheet a distance equal to the thickness of the sheet. Flange welds are usually made without adding welding rod and it is important that the operator obtain complete penetration to the bottom of the joint.

The flanged corner weld (sketches *B* in Fig. 1) is actually a modification of the butt-type flange weld. Since the two pieces to be joined meet at right angles, however, it is necessary to flange only one of the pieces for this type joint. Like the butt-type flange weld, the flanged corner weld also is usually made without the addition of welding rod and requires the same care on the part of the operator to secure complete penetration. This type of weld is widely used for joining flat heads to all types of light metal containers.

Sketches *C* in Fig. 1 show the open square butt-type joint most frequently used for welding tubing and for joining inlets and outlets to flanged openings in various types of vessels. This kind of joint may also be used in place of the butt-type flange weld. Welding rod is always required.

The flanged tee joint and variations of the unbalanced joint (sketches *D* in Fig. 1) are most commonly used for connecting side attachments or brackets to vessels and containers to accommodate supports or legs. Joints of this kind also are frequently found in the vessels themselves or in their superstructures wherever an edge and a flat surface, two edges of unequal thickness, or a flanged and a straight edge come together. Welding rod must be added to complete this type of joint successfully.

Properties of 18–8 Stainless Steel

Stainless steel differs from mild steel in many respects. The 18–8 grade, to which this discussion is confined, is so called because it contains approximately 18 per cent chromium and 8 per cent nickel. It is an iron-chromium-nickel steel with the following approximate composition:

Chromium	17 to 20 per cent
Nickel	8 to 11 per cent
Silicon	0.50 per cent (max.)

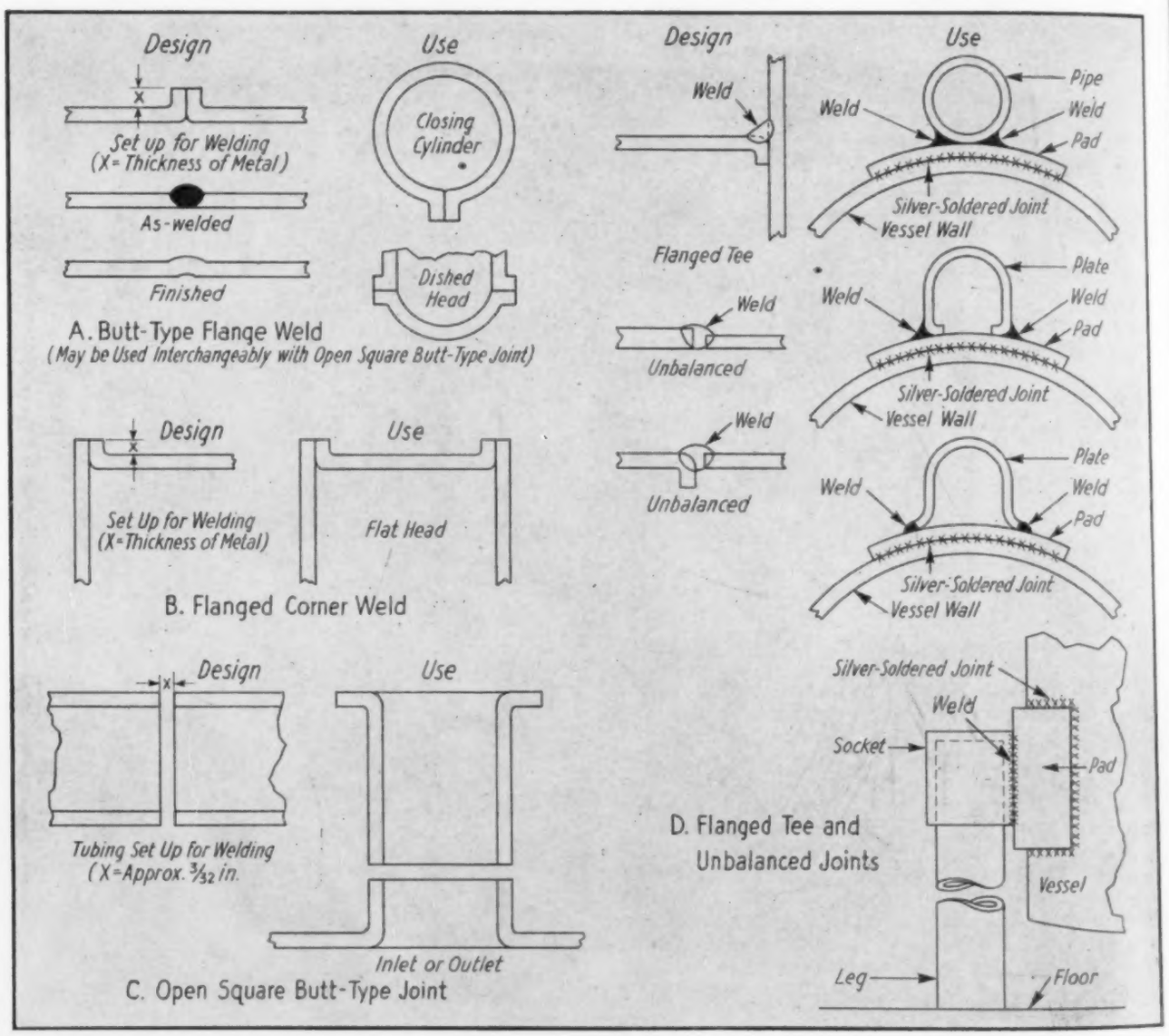


Fig. 1—Proper Joint Design Is Important for the Successful Fabrication of Stainless Steel Equipment. Joints Commonly Used for Light-Gage Metal Are Shown Here

Fig. 2—For the Butt-Type Flange Weld, First Flange Two 1½-In. by 6-In. Pieces of 18-Gage, 18–8 Stainless Steel as Shown in Fig. 1*A*. Then Thoroughly Clean Both Sides of the Flanged Portions with Fine Sand-Paper

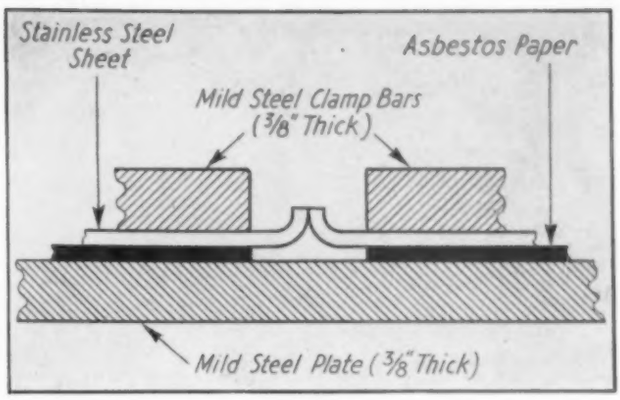


Fig. 4—Clamp the Fluxed Pieces, with Flanges Up and in Contact Along Their Entire Lengths, in a Simple Jig Such as This. Asbestos Sheet Provides for a Slight Air Space Below the Joint. The Steel Bars on Top Act as Chill Plates

Manganese	0.20 to 2.50 per cent
Carbon	0.05 to 0.14 per cent

Physical properties of 18–8 stainless steel are listed in Table 1. As mentioned previously, the most outstanding property of stainless steel is its corrosion resistance, which characteristic is due primarily to the presence of chromium.

When ordinary stainless steel is subjected to prolonged heating, as in welding, its corrosion resistance may be impaired by carbide formation, which is largely governed by the speed with which the metal is cooled between 1700 and 1800° F. Since thin metal cools much more rapidly following welding than does thick metal, the available time for possible carbide formation in thin metal is greatly reduced. Therefore in the light gages‡ of metal, impairment of corrosion resistance due to carbide formation is not usually important. However, in the heavier gages,‡ and for applications involving severe corrosion, it may be a serious factor.

Effects of Columbium or Titanium

For welded fabrication of equipment designed for use under severe corrosive conditions, manufacturers supply, at slight extra cost, a special grade of 18–8 stainless steel. This grade usually contains higher percentages of nickel and manganese which give it greater hot ductility, thus rendering it less subject to cracking due to thermal stresses resulting from welding. It also contains a small amount of columbium or titanium which is added during manufacture, and it is known as columbium- or titanium-bearing 18–8 stainless steel. Under conditions of high temperature, as encountered in welding, columbium and titanium combine preferentially with carbon, and the corrosion resistance of the metal is maintained.

‡ For purposes of this discussion, "light" sheet is considered as including 16-gage and thinner material; the "heavier" gages include sheet from 11 to 16 gage in thickness. Where welding is concerned, metal thicker than ⅛ in. (11 gage) is usually called "plate."

Table 1—Properties and Characteristics of 18–8 Stainless Steel

Yield point*
- Annealed—35,000 to 45,000 lb. per sq. in.
- Cold rolled—50,000 to 150,000 lb. per sq. in.

Tensile strength*
- Annealed—80,000 to 95,000 lb. per sq. in.
- Cold rolled—100,000 to 180,000 lb. per sq. in.

Elongation in 2 in. before breaking*
- Annealed—55 to 60 per cent
- Cold rolled—50 to 10 per cent

Brinell hardness number*
- Annealed—135 to 185
- Cold rolled—180 to 330

Melting range—2550 to 2600° F.

Scaling temperature—1650° F.

Heat treatment (ordinary 18–8)—Heat between 1900 and 2000° F. and quench in air or water (depending on thickness of metal)

Weight, per cu. in.—0.287 or 287/1000 of 1 lb.

* At room temperature of approx. 70° F.

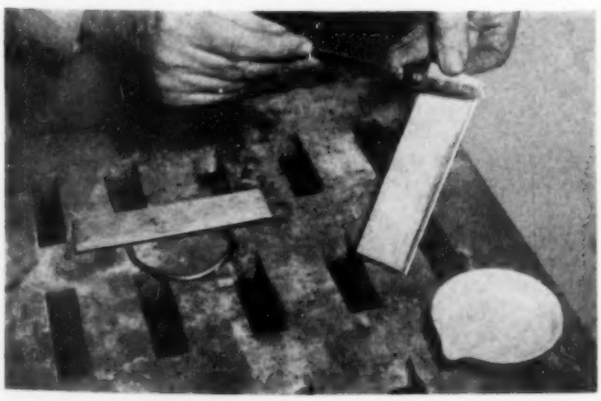


Fig. 3—In a Non-Metallic Container, Mix Some Cromaloy Flux and Water, to About the Consistency of Milk. Apply a Coating of This Mixture to Both Sides of the Sandpapered Flanges with a Small Brush and Allow It to Dry

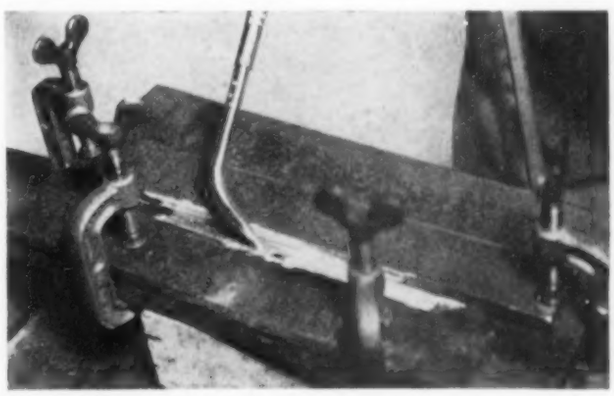


Fig. 5—Use a Welding Tip One or Two Sizes Smaller Than That Recommended for Mild Steel Sheet of the Same Thickness. Adjust the Flame to Neutral or Only Slightly Carburizing

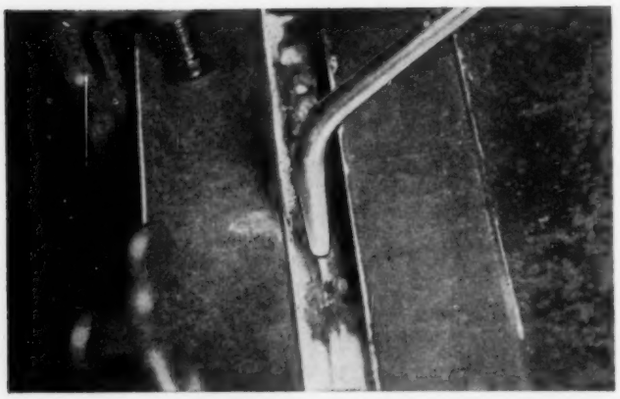


Fig. 6—Without Using Rod, Melt Down the Flange as Weld Metal. Hold the Tip of the Inner Cone About 1/16 In. from the Molten Puddle and Point the Flame Along the Weld at an Angle of About 80° to the Surface of the Sheet

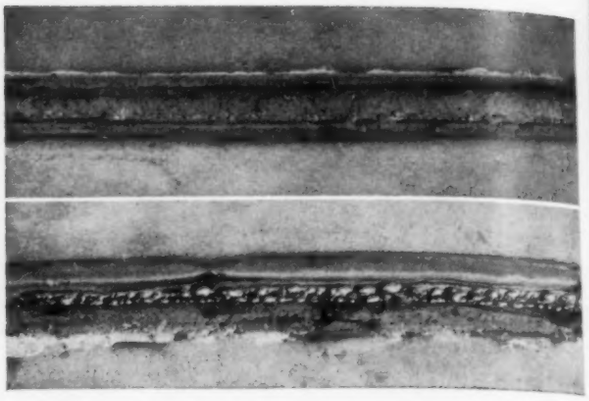


Fig. 8—A Good Specimen Will Look Like This When It is Removed from the Jig. Observe That the Front of the Weld (Top) Is of Regular Height and Width. The Back (Bottom) Shows Little Globules Indicating Complete Penetration

Columbium- or titanium-bearing 18–8 stainless steel can be readily obtained from any supplier by specifying type numbers assigned by the American Iron and Steel Institute. The types best suited for welding are numbers 321, which contains titanium, and 347, which is columbium treated. Both types are to be preferred in the annealed rather than the cold-rolled state because of the greater ease with which the annealed metal can be flanged or otherwise cold worked.

Preparation for Welding

Light sheet is usually flanged before welding, as shown in Fig. 1. The size of the flange is determined by the thickness of the sheet, the upstanding edge of the flange being made to extend above the top surface of the sheet for a distance equal to the thickness of the sheet. Edges to be joined must be completely free of foreign matter before welding is attempted. Highly polished stainless steel rarely requires cleaning, but dull, scaled (as a result of the annealing treatment) and dirty surfaces should always be cleaned carefully with fine sandpaper. Thoroughly clean both sides of the entire flanged portion of the sheet to a point just beyond the bend toward the sheet proper.

Never use emery cloth, or *ordinary* steel wool or wire brushes for cleaning purposes. Fine sandpaper is preferable but soft, cushion-type fabric wheels, *stainless* steel wool, or wire brushes of *stainless* steel may be used *provided they have not been used on metals other than stainless steel of similar type.* It is important that materials used for this work be free of contamination by other metals, particularly plain iron and mild steel.

Jigs and Fixtures

Heated 18–8 stainless steel sheet expands about 50 per cent more than similarly heated mild steel sheet and, for this reason, particular attention must be given to expansion and contraction during welding. Adequate control is provided by the use of jigs and fixtures, chill plates (preferably copper), and sometimes by the careful preheating of large surfaces in special jigs. Jigging arrangements for stainless steel sheet are identical with those used for ordinary sheet metal of mild steel.

Where long seams are to be welded, or the assembly is such that it cannot conveniently be set up in adequate jigs, the parts may be tack welded at short intervals.

Table 2—Recommended Rod Size

Thickness of Metal	Recommended Rod Diameter, In.
18 gage and lighter	1/16
18 to 16 gage	1/16 to 3/32
16 to 10 gage	3/32 to 1/8
10 gage to 3/16 in.	1/8 to 5/32
1/4 in. and heavier	3/16 to 1/4

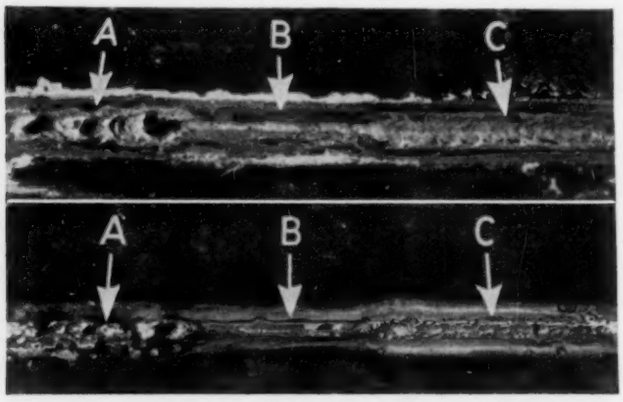


Fig. 7—Compare the Practice Specimen with Front (Top) and Rear (Bottom) Views of the "As-Welded" Joint Shown Here. Sections Indicate (A) Overheating of Sheet: (B) Insufficient Melting of Flange: (C) Acceptable Student Weld

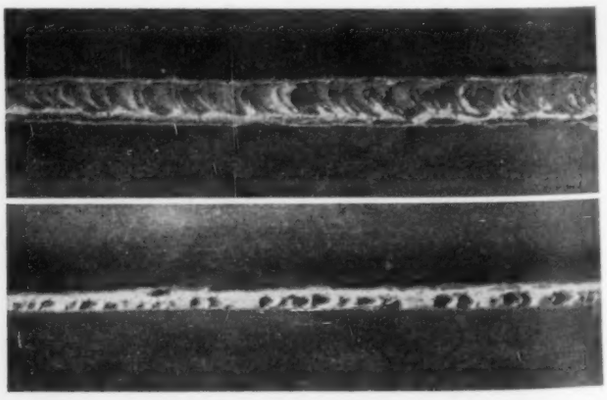


Fig. 9—After Scale and Oxides Have Been Removed, the Weld Should Compare Favorably with the Front (Top) and Rear (Bottom) Views Above. Slight Unevenness of Rippled Surface Is Due to the Modified Welding Technique Employed

these tack welds may be as close together as 3/4 in. if desired. As a general rule, sheets of gage thicknesses usually require a spacing of approximately one-half of the thickness of the sheet. Flanged joints are set up without spacing. All seams should be accurately aligned at the start and clamped together in some manner prior to the tack-welding operation.

Flux

Special stainless steel flux must be used in welding 18-8 sheet. Oxides formed during the welding of this metal will not dissolve in ordinary fluxes such as are used for cast iron, brass, copper, bronze and aluminum. Cromaloy flux is prepared specifically for use with stainless steel and serves to dissolve undesirable oxides.

Before welding is started, the flux is applied to the sheet so as to cover the entire surfaces previously cleaned for joining. This may be done either on both sides of the sheet or, when the operator is experienced, on one side only. In the latter event, the bottom or back rather than the front or top of the weld is the surface which is always covered. To aid its application, the dry flux is first mixed with water in a glass, porcelain or other nonmetallic container. The mixture, of about the consistency of milk, can be readily painted over the joint by means of a small brush. On some occasions it may also be found convenient to coat the welding rod with the flux mixture. This is best accomplished by heating the rod slightly before brushing the liquid over it.

Welding a Stainless Steel Mixing Tank for Use in the Chemical Industry

Part II: Welding Rod, Flame Adjustment, Welding Technique and Weld Finishing Procedures

TO maintain full corrosion resistance of the welds, welding rods are used which contain slightly greater percentages of chromium, manganese and silicon than the base metal. The slight excess of these elements allows for the small oxidation losses that are apt to occur during welding even when the molten metal is protected by a neutral flame. A suitable columbium-bearing 18-8 stainless steel welding rod is recommended for all stainless steel welding regardless of whether or not the base metal contains columbium or titanium. This rod provides an excellent color match and its composition insures uniformly high-grade weld metal under usual welding conditions. Its melting point is about 2590° F.

Choice of welding rod size is dependent upon the thickness of the metal to be welded. In general, the same relationship between rod diameter and thickness of base

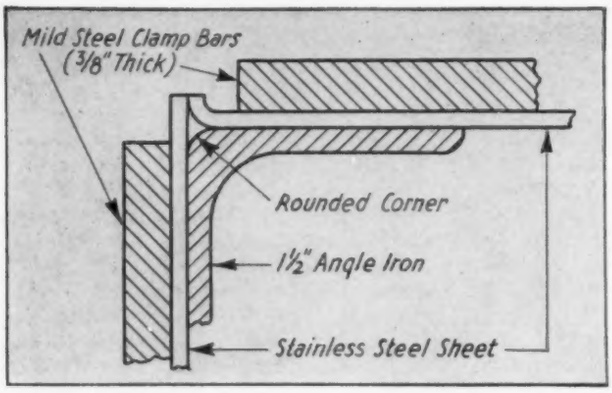


Fig. 10—For the Flanged Corner Weld, Prepare Two Pieces of 18-Gage, 18–8 Stainless Sheet as Shown in Figs. 1*b*, 2 and 3. Then Clamp the Parts in a Jig Like This. For Best Results the Corner of the Angle Iron Should Be Rounded

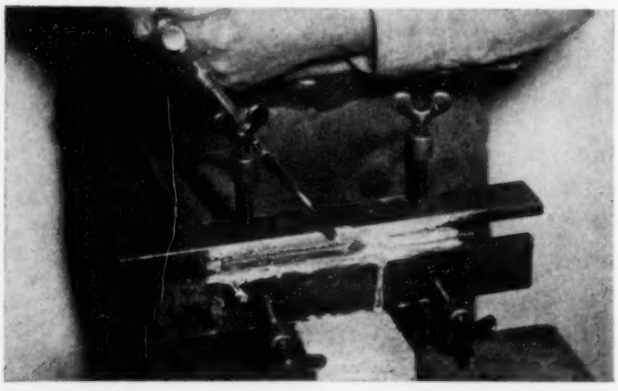


Fig. 11—Welding Technique Is Exactly the Same as That for the Butt Type Flange Weld Shown in Figs. 5 and 6. Hold the Neutral Flame Produced by the No. 4 Welding Tip at an Angle of About 80° to the Surface of the Sheet

metal prevails as for mild steel. The diameter of the proper-size welding rod is usually approximately equal to or slightly less than the thickness of the metal to be welded. Recommended sizes of welding rod for various thicknesses of 18–8 stainless steel are listed in Table 2.

Flame Adjustment

The proper flame for welding 18–8 stainless steel is one that is strictly neutral, because the neutral flame protects the molten weld metal from reactive welding gases and from the atmosphere. A flame that is strongly oxidizing causes a porous weld. A strongly carburizing flame also is undesirable because it modifies the corrosion resistance and decreases the ductility of the metal. If difficulty is experienced in maintaining a strictly neutral flame, the blowpipe may be adjusted so that the flame shows a slight excess of acetylene rather than an excess of oxygen which is to be avoided. The adjustment is just sufficiently on the excess acetylene side to insure against an oxidizing flame. Under no circumstances should the excess acetylene feather project more than $^1/_{16}$ in. beyond the tip of the inner cone, as seen through welding goggles. Proper adjustment of the flame is important for maintaining the best corrosion resistance and securing sound welds.

Welding Technique

In general, the technique for welding 18–8 stainless steel is similar to that for mild steel sheet of similar thickness. The welding tip employed is always one or two sizes smaller than the size recommended for the same thickness of mild carbon steel. The smaller flame produced by the smaller tip is desirable because the heat conductivity of 18–8 stainless steel is about 40 to 50 per cent less than that of mild steel. In other words, since heat tends to remain longer in the weld zones of 18–8 stainless steel, the use of the smaller flame helps to avoid unnecessary or excessive heating and less oxygen and acetylene are consumed than for welding mild steel of similar thickness.

The angle at which the blowpipe flame is held is somewhat steeper than for plain carbon steel. An angle of about 80° to the surface of the sheet is recommended. The tip of the inner cone of the neutral flame is maintained at a distance of not less than $^1/_{16}$ in. from the surface of the molten puddle. Contact between the inner cone and the hot metal should be avoided since such contact has a tendency to overheat small areas and lead to porosity in the weld. With the welding flame held in proper position, the molten metal is protected from the oxygen in the air by the neutral atmosphere of the outer envelope.

Welding is accomplished with as little disturbance or puddling of the molten metal as possible. Puddling is avoided because it increases the tendency toward oxidation and removal of valuable elements. Normal heat keeps such losses to a small allowable percentage of the amount of columbium contained in the welding rod.

The preferred welding technique consists in holding the rod ahead of the blowpipe so that the weld metal melts in place or is melted simultaneously with the base

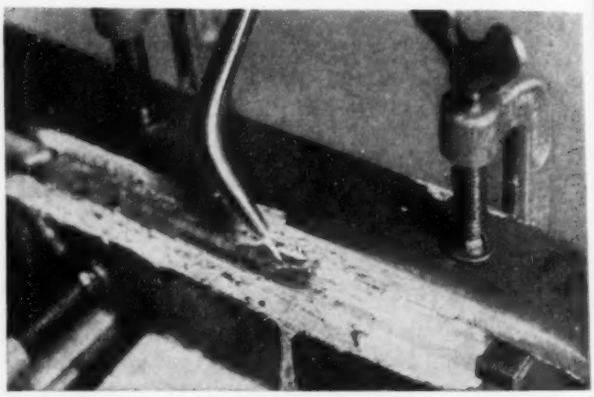


Fig. 12—Weld Metal Is Obtained by Melting Down the Flange. Be Careful to Obtain Complete Penetration but Do Not Allow the Tip of the Inner Cone to Touch the Molten Metal. Speed of Welding Is Somewhat Faster Than for Mild Steel

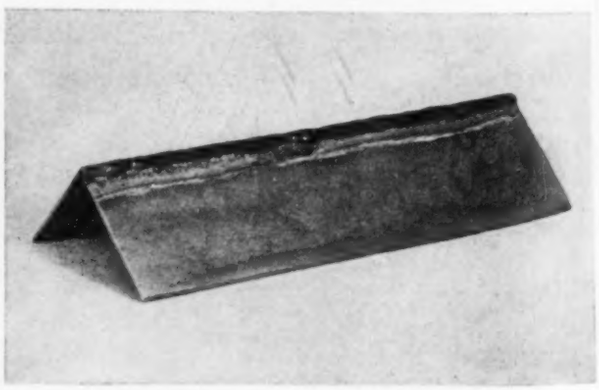


Fig. 13—Here Is a Completed Corner Joint in the "As-Welded" Condition. When the Weld Is Finished, the Sharp Inside Corner May Be Rounded Out with Silver Solder to Prevent Food or Other Substances from Lodging in the Crevice

metal to form a union between the parts being joined. The choice between forehand and backhand welding depends chiefly upon the skill of the operator in either method. In general, forehand welding is preferable on light-gage sheet, while backhand welding is better on the heavier gages.

It is important not to stop or rework a hot weld. Stainless steel welds are preferably completed in a single pass. Thorough penetration should be obtained in this one pass so that it is not necessary to work over or touch up the weld in any way. If it is necessary for any reason to go back over a weld, preheat the partially welded joint with the blowpipe for a reasonable distance ahead of the point of welding and repeat as necessary until the joint is completed. This practice will help to minimize warpage and stresses due to localized heating, but such preheating should be kept within the black heat range and should not exceed a temperature of about 500° F.

In joining long, tack-welded seams, it may be found helpful to use a modified "back-step" method to overcome buckling and distortion in the "unjigged" sheets. This

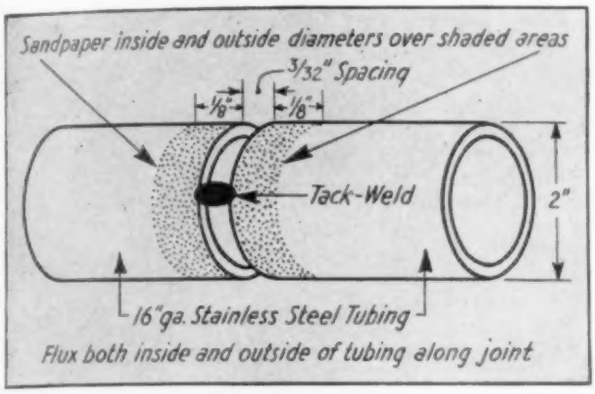


Fig. 14—To Weld Stainless Tubing, Prepare the Ends as Shown Here and Align the Parts in a Section of Angle Iron. Tack-Weld at Three Equally Spaced Points with 1/16-In. Columbium-Bearing 18-8 Stainless Steel Rod

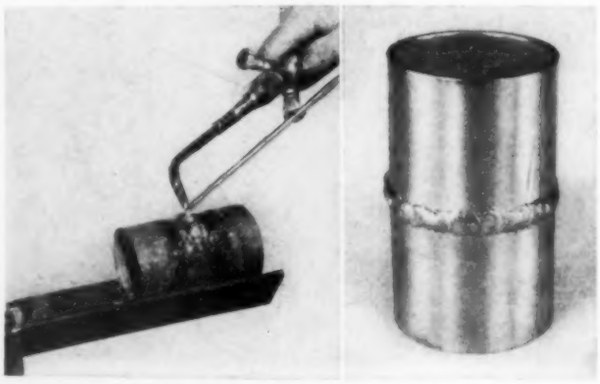


Fig. 15—(Left) While Welding, Rotate the Tubing to Permit Working in the Most Convenient Position and Melt Out Each Tack-Weld to Insure Penetration. (Right) Compare the Result with This Cleaned but Unground Specimen

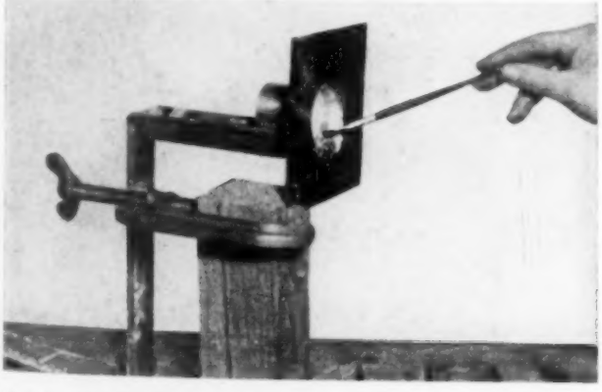


Fig. 16—The Procedure for Joining an Inlet or an Outlet to a Flanged Opening Is Identical with That Employed in Making an Open Square Butt-Type Joint (Figs. 14 and 15). Here the Operator Is Fluxing the Inside of the Joint

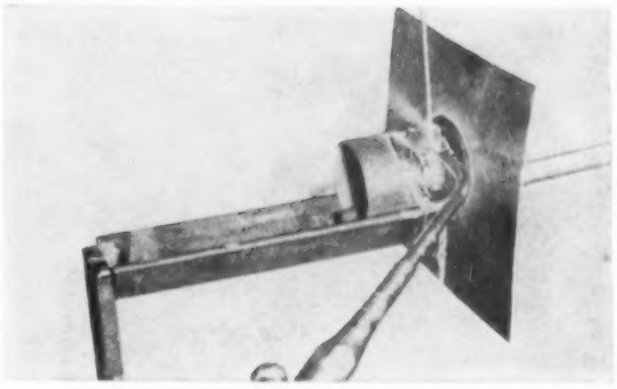


Fig. 17—Tack-Weld the Parts at Three Point 120° Apart and Join Them with 1/16-In. Rod, Using a Neutral Flame and No. 4 Tip. For Practice in Position Welding, Try to Make the Joint Without Rotating the Work

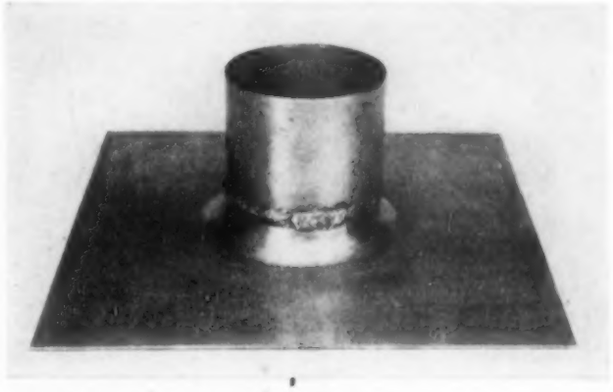


Fig. 18—Here Is How the Completed Weld Appears from the Outside After Flux Residue and Oxides Have Been Cleaned Away. The Weld Reinforcement May Be Ground Down, if Desired, to Improve the Appearance of the Joint

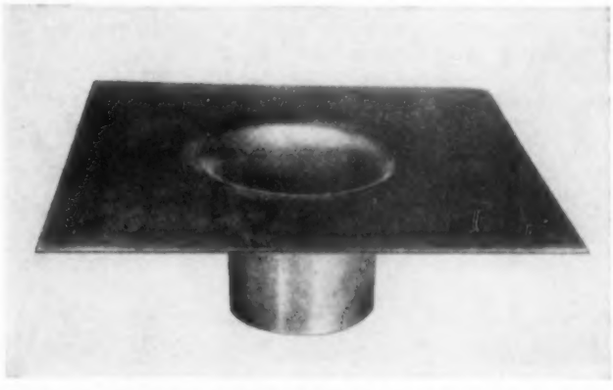


Fig. 19—The Inside of the Same Finished Joint Presents a Smooth, Crevice-Free Surface. Both Flange and Tubing Appear to Be and Are Now Essentially a Single Piece of Stainless Steel as the Result of the Fusion-Welding Operation

In joining long, tack-welded seams, it may be found helpful to use a modified "back-step" method to overcome buckling and distortion in the "unjigged" sheets. This

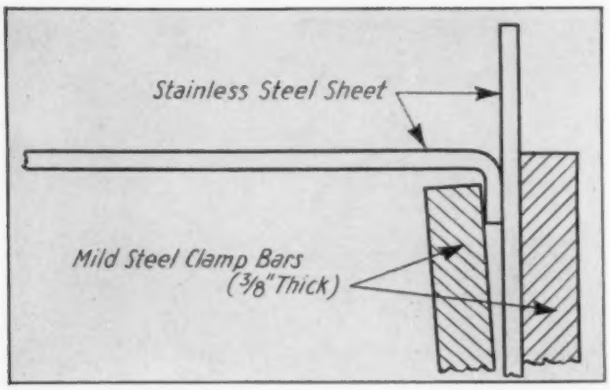


Fig. 20—For the Flanged Tee Joint, Take Two 1 1/2-In. by 6-In. Pieces of Annealed 18-Gage Stainless Sheet and Flange One 6-In. Edge. Sandpaper and Flux Both Sides of Both Parts Along the Line of Weld and Clamp in a Jig as Shown

Fig. 21—Using a No. 4 Tip, Neutral Flame, 1/16-In. Rod, and the Same Welding Technique as for Previous Exercises, Make a Fillet Weld Along the Joint. Direct the Flame Equally Over Both Sheets to Prevent Uneven Heating

practice involves the welding of a short section, after which the rod and flame are advanced a short distance along the unwelded joint. At this point, welding is begun again and carried back to meet the previous section of weld. The procedure is repeated along the entire seam.

Heat-Treatment

Columbium- or titanium-bearing stainless steels require no heat treatment after welding since they retain full corrosion resistance. Ordinary stainless steels, in the heavier gages or for use under severe corrosive conditions, may require heat treatment for re-establishing the corrosion resistance in areas affected by the heat of welding. Since such heat treatment varies with different types of stainless steels, it is recommended that the user obtain specific details about heat treating from his source of metal supply.

Finishing of Welds

Procedures for finishing stainless steel are quite different from those employed for mild steel and improper handling of this stage might well result in damage to the welded vessel or container. For specific instruction on this phase of the work, the supplier of the stainless steel should be consulted. In any event, all traces of flux residue should first be removed from the weld. This can be accomplished with hot water or a weak solution of nitric acid used in accordance with the steel manufacturer's recommendations. Certain other general considerations are also recorded here as a guide against poor practices.

Ordinarily, only one surface of the weld will require finishing. Also, the side opposite that from which welding is done usually has considerably less surplus metal and, because of this, requires less time and labor for finishing. Therefore, it is good practice, wherever possible, to weld from the side opposite that to be finished. Scale or oxide, whether formed during annealing or by the heat of the welding operation, must be com-

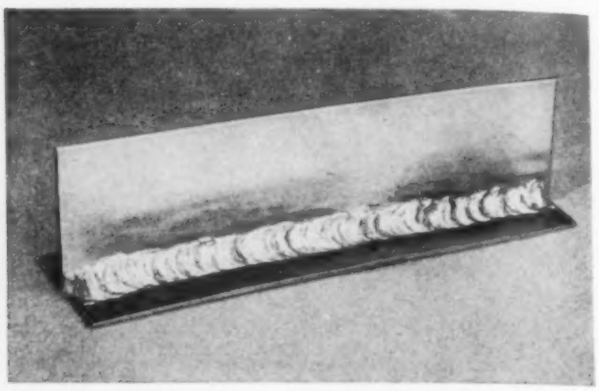


Fig. 22—Here Is a Front View of the Finished Flanged Tee Joint, Commonly Used as Shown in Fig. 1*d* for Joining Side Attachments and Brackets to Vessels or Containers. Grind Down the Surface of the Weld to Improve Its Appearance

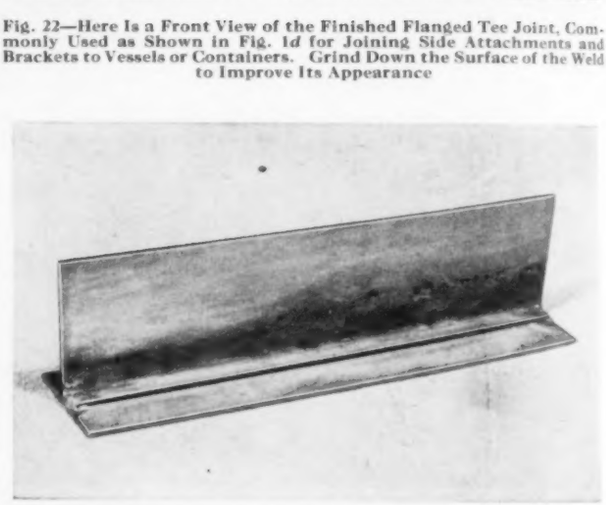
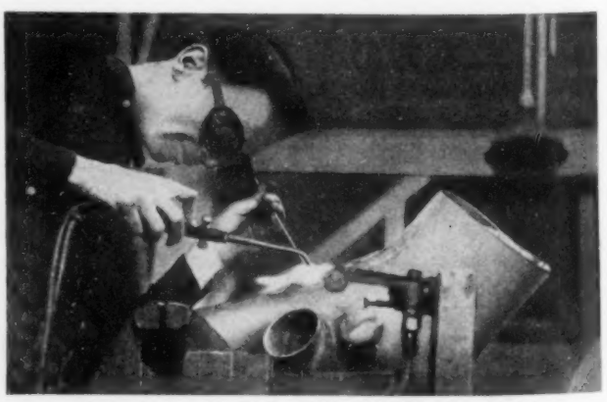


Fig. 23—A Rear View Shows That the Weld Does Not Penetrate Through the Entire Flange but This Does Not Affect the Usefulness of the Joint Under Ordinary Conditions. When Necessary, Round Out the Crevice with Silver Solder



Welding a Stainless Steel Collector Ring Used in Aircraft Construction

pletely removed since it is almost certain to rust. If not removed, such scale is likely to cause corrosive attack and pitting of the stainless steel base metal. Scale is usually removed by sandblasting or treating with acid by the method known as pickling. Welded assemblies for severe corrosive service are often annealed and pickled.

Excess weld metal should be removed with solid grinding wheels of suitable grit. Where necessary to match the mill finish, grinding may be followed by polishing and buffing with cloth, leather, felt or other type wheels which may be either dry or lubricated. Soft, cushion-type, fabric wheels of sewed, unbleached muslin disks are usually recommended for this polishing operation.

Grinding is best done along the weld rather than across it because it is almost impossible, in cross grinding, to avoid cutting into the metal surfaces adjacent to the weld. Also, grinding should be carried along continually in one direction.

The grinding wheel should not be allowed to remain long in any one spot. Since stainless steels are poor conductors of heat, they "burn" far more easily than mild steel and "burning" tends to cause buckling and to lower the corrosion resistance of the metal. If an area becomes hot to the hand, grinding should then be continued at some other weld area until the former area cools. Sometimes, to prevent overheating, wet rags or sponges may be applied frequently to the surface being ground.

Excessive pressure of the grinding wheel will also result in "burning" of the metal. Moreover, work cannot be hurried by putting heavy pressure on the wheel, for cutting efficiency depends mainly upon grit size and wheel speed. Light-gage material should be backed up with steel plate or wooden blocks to provide a firm surface for the wheel.

All wheels and buffs for grinding and polishing stainless steel must be free of contamination by other metal in order to avoid discoloration or rusting of the contaminated weld in service. Only freshly dressed grinding wheels should be used and polishing wheels and buffs should be reserved for use on stainless steel only. Abrasives for use on stainless steel must also be iron free.

Spot Welding of Aluminum Alloy for Aircraft

By L. M. Benkert*

A NEW, high-speed production process for spot welding aluminum alloy sheet for aircraft has just been announced by our company. Involving an entirely new principle of operation, the process produces welds in aluminum alloy with a uniformity equal to that possible in welding steel in production and thus may prove to be a simple solution to the problem of mass production of airplanes.

Capable of producing spot welds in aluminum alloys far beyond the strength required by government specifications, the new process involves no costly or complicated "energy accumulators" and does not require any special skill on the part of the operator. Welding speeds are directly in line with those customary in the welding of sheet steel and are limited largely only by the speeds at which the work can be moved between welds.

In addition to showing a striking uniformity, welds

* General Manager, Progressive Welder Company.

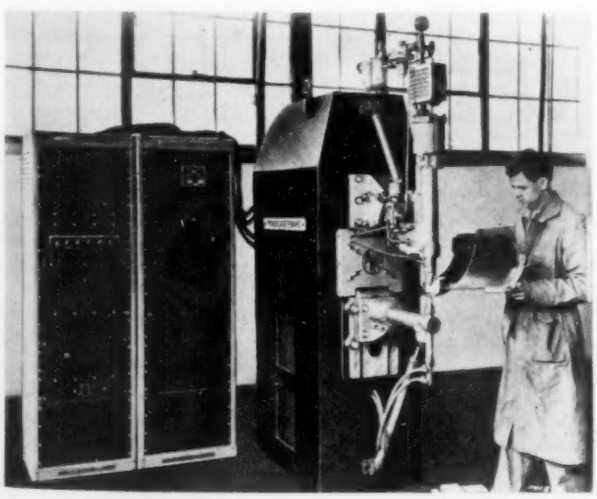


Fig. 1—Simplified, Standardized Aluminum Spot Welder Employs All Three Phases of 3-Phase Current to Gain Required High Welding Currents and to Produce Uniform Welds Having Twice the Strength of Government Requirements. Timer Control, Which Is 100 Per Cent Electrical, Is Mounted on Panel at Left

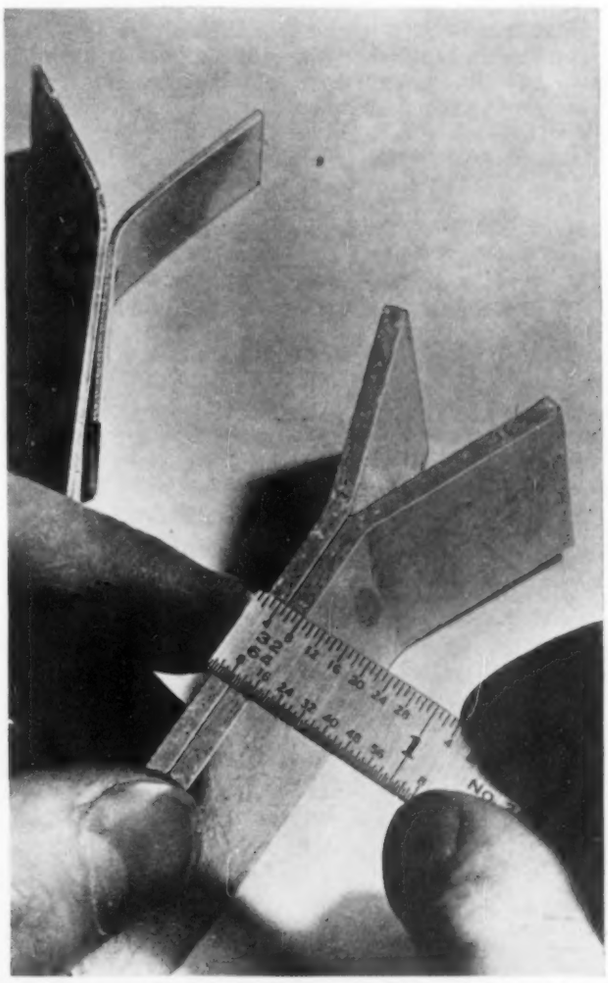


Fig. 2—Unprecedented Range of Capacity of One Aluminum Welding Machine Is Indicated by These Two Samples Welded by the Same Machine Within a Few Moments of Each Other; Two Pieces of 1/8 In. and Two Sections of 0.032 In., 24 S. T. Aluminum

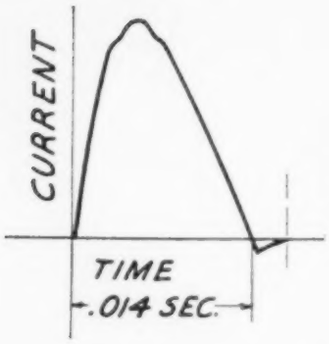


Fig. 3—Best Welding Current Wave for Aluminum Alloy Sheet Is Steep-Walled with "Sustained" Rather Than Sharply Peaked Form During the Weld. This Drawing Is from Oscillograph Recording Made During an Actual Weld

made with this process are apparently entirely free from cracks and blow-holes. Not only is the actual operation of the machine exceedingly simple but only two adjustments are required to take care of all conceivable types of welding operations within the capacity of the machine.

The principle on which the equipment operates is based on the use of all 3 phases of 3-phase alternating current, the proper wave form for the weld being developed in such a manner as to permit accuracy of control of welding current. The flexibility of equipment permits the welding of aluminum sections totaling $^1/_4$ in. in thickness down to the thinnest weldable sheet on the same machine. It is possible, for instance, to spot weld 7 pieces of 0.032-in. section 24 S. T. Aluminum sheet with a 150 kva. 3-phase welder.

Shear-strength tests made on fifty samples selected out of 100 run under operating conditions which simulate actual conditions show a better than 100 per cent margin over government requirements. They show weld strength variations to be not over 5 per cent from the average.

Aluminum Welding Problems

As have been demonstrated by every attempt, the welding of aluminum is at best very difficult. It has little resistance to the passage of current and thus requires a large amount of current to obtain a weld. Since its plastic range is so extremely short, the current must be "on" for a very short interval. Welding pressure must be accurately controlled and carefully balanced with the amount of current applied in order that excessive surface indentation does not result.

Of the various complications, the problem of supplying sufficient current to the work is possibly the greatest and has been approached in the past in several ways, among them being the use of: capacitor banks; motor generator sets; the charging of a capacitor bank by direct current followed by discharge through the primary circuit of a welding transformer, etc. Difficulty with these methods of approach is lack of positive control of "output" or welding current so necessary for uniformity, in addition to the mechanical costs involved. If to this is added the slowness in operation and complications of earlier welding equipment, etc., it is not difficult to understand why welding for aircraft construction has failed to develop to the same extent as in the automobile industry.

Three-Phase Process

The new 3-phase short wave process consists, essentially, of passing the current through a converter, which eliminates the negative portions of the wave. The resulting pulsating current has a time cycle of 300° instead of the 360° (see Fig. 4 (*A*, *B* and *C*)). The current then passes through the welding transformer amplifying the current. The resulting secondary current wave form is ideal for the welding of aluminum (Fig. 4 *D*). The current rises to its maximum almost instantly, stays at this value for practically the entire duration of the weld, then drops to zero in an extremely short period of time.

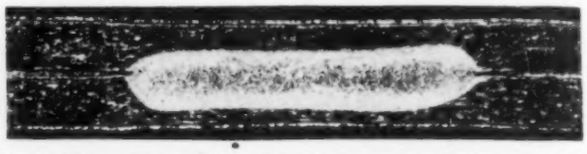


Fig. 5—Photomicrograph of Typical Specimen Weld Shows Satisfactory Grain Structure Free from Cracks, Blow-Holes, Etc.

A timer panel for the various sequences of the welding operation which also houses the ignitron tubes, provides completely automatic operation for an unusually wide range of aluminum welding operations. With it weld time can be anywhere from the maximum, $^1/_{12}$ of a second, down to zero. Thus, the adjustment provides for correct welding time for any conceivable aluminum spot-welding job from the thinnest weldable sheet up to two $^1/_8$ x $^1/_8$ sections and is obtained by simple manipulation of but two control knobs on the panel.

The complete equipment, mechanically, is almost identical with standard pedestral-type welding equipment. Welding pressures are obtained through a standard direct air-operated pressure cylinder which is mounted on the upper arm and actuates the upper welding electrode, and are so handled as to provide a "follow-through." To provide a closer and more positive connection between welding transformer and work, an air-operated secondary shunt clamp grips the upper electrode after the work is under welding pressure.

Automatic repeat timing, which allows sufficient interval between welds to reposition the work, permits making any number of welds in succession automatically without reclosing the pilot device for each weld.

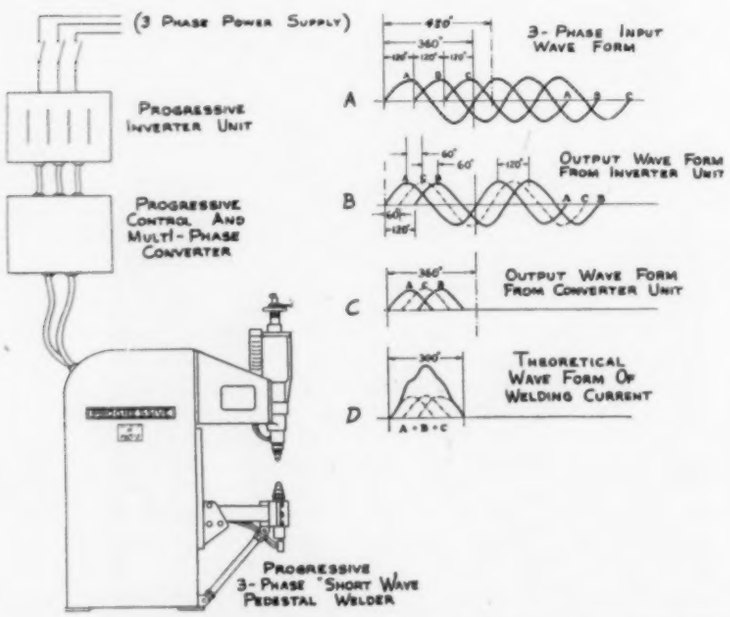


Fig. 4—Schematic Diagram Indicating How 3-Phase Alternating Current Is Converted to Produce Sufficient Current for Welding Aluminum Without Complicated or Costly Equipment. Resulting Pulsating Current Has a Time Cycle of 300° Instead of the Original 360°. Resulting Current Then Passes Through Welding Transformer

The Lining of Towers by Stainless Alloy Steels*

By Robert Lee Looney†

ARC welding has played a very important part in the great petroleum industry through a decade of constant growth. And in the field of the petroleum industry great strides have been taken not only in its adaptation to new uses and expansion of its former fields, but also in its development along the lines of greater efficiency and economy of manufacture. New methods of production from the seeking of raw material in the ground to the final refined product have necessitated the keeping pace by the suppliers of equipment used in production and refining of oil and its kindred products. A few years ago steels were composed of a few basic formulas. Today it is truly a day of *Alloys*. Modern activities are based to a greater extent on the use of steels to which sufficient amounts of alloying ingredients have been added to obtain certain desired results.

Less than fifteen years of time have been consumed in bringing about this advance in alloy materials up to its present-day uses, most of this advance having been made in the last ten years.

Little was known in the early days about alloyed steels and their application by the process of arc welding. However, about 1928 shielded arc electrodes were recognized and pointed toward a more promising future in the expanded use of alloys. The old-style bare electrode had inherent weaknesses overcome by the addition of the flux coating. This flux coating has four important purposes: (1) forms a gaseous shield around the molten weld to prevent oxidation of the flowing metal; (2) forms a slag over the completed weld to prevent oxidation during cooling; (3) this slag slows up the cooling rate, decreasing air hardening and brittleness; (4) sometimes the flux coating also contains a portion of some stabilizing element. It also must be understood that the steel manufacturer played an important part, through laboratory and engineering research, to advance the weldability of alloyed steels.

New refining methods required the solution of three problems. Increases in both temperature and pressure resulted in greater corrosion and erosion. This necessitated more resistance to corrosion, scaling or oxidation. Higher temperatures in the new refining processes resulted, during rapid changes of temperature when cleaning towers both when bringing them down rapidly and when putting the tower back in operation when temperatures are increased very fast, in the need of a substance (steels) to give more creep strength. So we have the new steels designed to relieve corrosion, scaling or oxidation, and to give added creep strength, namely, alloyed steels, and particularly those known as stainless steels.

In the early days it was the consensus of opinion that it was necessary to go to the higher analysis in alloy steel, those of 18–8 and 25–12 stainless, to obtain the resistance to corrosion, scaling or oxidation, and to strengthen against creep action at the high temperatures defined by the needs of the oil industry. Any one of these conditions was bad enough to combat in the refining process of crude oils, but taken together it created a serious problem.

The foregoing conditions prevailing, one of the major oil companies decided to allow the writer to engineer, and assist in lining, one of their refinery Bubble Towers in the Gulf Coast area in the spring of 1930. We used 18–8 stainless, 10-gage sheet, in 24-in. by 6-ft. strips.

The tower was cleared of all mechanical obstruction and the result of chemical decomposition, and cleaned of coke, preparatory to sandblasting. Too much emphasis cannot be placed on this cleaning operation preparatory to welding, as a clean surface, free from all impurities, especially carbon, must be furnished to the welder to secure a good bond with a minimum of hardening. The sand used on this job was known as fine-screened granite chat which proved to be very successful in securing a thoroughly clean wall surface. After carefully scaffolding the tower, the coiled 18–8 stainless 10-gage strips were carried into the tower through the manholes and placed horizontally on wall of the tower by a special mechanical tool to insure a close fit-up of liner strip. Then the liner strip was properly tack welded preparatory to welding procedure.

Welding was as follows: Strips were placed horizontally end to end and vertically side by side, allowing $^1/_4$ in. space between strips, and strips placed above each other one-half length of sheet so the vertical joint would not come in line, with plug welding procedure to be followed, plugs being $^3/_4$ in. in size and spaced on 5-in. centers. Shield arc electrodes of $^1/_8$-in. 18–8 variety were used for welding liner to wall of tower; using welding current 115 amperes and 24 to 26 volts across arc.

All plug welds were completed by welding bead around outer edge of hole to wall of tower first, then cleaning the bead, finishing filling the hole by welding up hill. All plug welds were completed on each sheet before the outer edges of the stainless strip were welded securely to the tower wall. The outer edge of the strip was first welded horizontally with one bead on the edge of each side of the strip to the wall of the tower, then the vertical edges, leaving about $^1/_8$ in. between beads, sandblasted and visually inspected for any defects, before final finish bead or pass was made. After the tower walls were completed, the dome and bottom were fitted and welded in a similar manner, using sheet liner strips cut to properly fit contour. All manhole and covers were lined.

After the tower was completed, each individual liner strip was tested by air pressure and soapsuds to insure no defects in the tower liner. To the writer's knowledge, this tower was in continuous service for nine years without any further corrosion being present. It would prob-

* Presented at the Oklahoma University Welding Conference.
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ably still be in service if newer refining methods had not been developed necessitating its discontinuance.

This particular job proved very successful; however, other reports indicate some difficulties have been encountered with plug welds on lining jobs. Some plug-welded lining jobs proved unsuccessful on account of plug welds failing, in some instances, in the bond between the stainless liner strips and the tower wall. We therefore changed to strips 4 in. wide by 40 in. long, placing strips vertically, spacing $^{7}/_{32}$ in. between strips, and welding with $^{1}/_{8}$-in. 18–8 stainless electrodes one bead, or pass, up hill. The material used on one particular lining job was 4–6 chromium and the job was done in 1936. It has proved very satisfactory in every respect.

There has also been one job put in, running 4-in. strips horizontally around the wall of the tower leaving approximately $^{1}/_{4}$-in. space between liner strips, and welded with 3 beads. This has some drawbacks on account of trapping slag inclusions in the molten metal while welding operation is in procedure, necessitating some patchwork. With this method it is also hard to secure a perfect fit-up in the contour of the wall of the tower, due to uneven corrosion and pitted spots that sometimes give considerable difficulty, and being unable to press the liner strip tightly against the wall of the tower which is very necessary in order to secure a good welding job.

In our opinion the more successful future jobs will be put in with 4–6 chrome strip. The cost of material will be much less and yet it will last six to eight years. This length of life, of the liner, will be sufficient as most of the towers being lined are already old and the 4–6 alloy is sufficient to outlast present distillation procedure; that is, advancement in the oil industry will, in a few years, discontinue use of present old towers.

The 4–6 chrome strips, of 10-gage material 4 in. wide and 30 in. long, should be placed at a 45° angle on the wall of the tower, spaced $^{1}/_{4}$ in., 3 beads used. This *new* procedure will enable the operator to produce a sound, good quality weld with less effort and with a saving in time. Also it will relieve some stresses and strains caused by rapid heating and cooling of the towers in cleaning them out.

An 18–8 stabilized stainless electrode has proved highly efficient in welding 4–6 chrome strips thus giving an added saving in the cost of electrode used. This *new* method will result in greater interest in the lining of towers for the petroleum industry. In the past the cost of the job has not been commensurate with results obtained so that the method could not be universally adopted. However, with a much reduced first cost and sufficient length of life to insure maximum utility of the tower, a large percentage of the present towers can profitably be lined.

Some contention has been made that strips 3 in. wide by 30 in. long should be used. However, the difference in cost of strips, erection, welding time and cost of increased amount of electrode needed, which would add about 25% to total cost of the job, eliminates this size strip on the lower chromium-bearing lining jobs. It might be good logic on the higher chromium alloys to go to the 3-in. strip because of the long life anticipated and the increased creep strength.

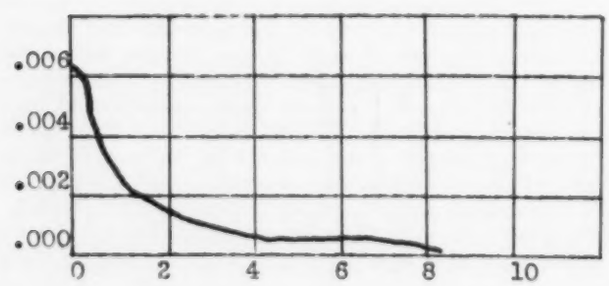

Fig. 1

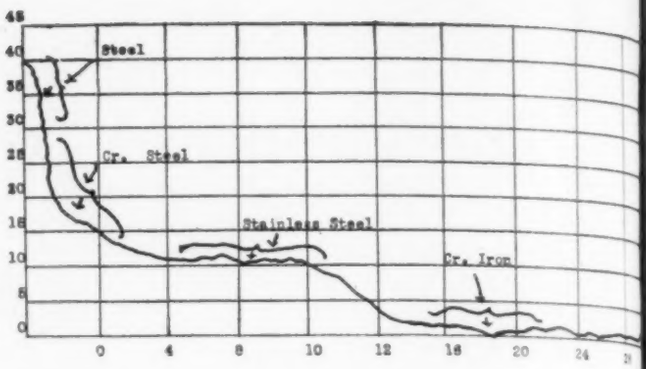

Fig. 2

The weldability of 4–6 chrome strips with 18–8 stainless *stabilized* electrode has been proved under actual field conditions. The welding operation, for the average first-class welder to produce a good sound quality weld, is much easier with a columbium stabilized rod than with some other alloys that have been tried. The columbium stabilized rod does not have the tendency to give as much air-hardening effect in the junction of fusion zone as have some other alloys that have been tried out on other lining jobs. In an article by Weldon L. Archer in the January 1941 issue of *Refiner and Natural Gasoline Manufacturer* Archer reports his thorough investigation on the advantage of the columbium stabilized electrode. You will notice in the chart (Fig. 1) the relation of corrosion rate and chromium content of steels when handling certain corrosive crudes at high temperatures and pressure. The difference of corrosion penetration between 4–6 chromium and up to 9% chromium is negligible. This chart represents the investigation of Dixon.

This, then, was the start. In Archer's article he goes on to state that "immediately following the selection of this range, thousands of tubes were manufactured for the petroleum industry using the 5% chromium analysis —studies of fifteen different alloys were conducted in 10 separate refineries."

The tests given these alloys included:

A.—Service Tests in Evaporators—Vapor Phase
B.—Service Tests in Oil Cracking Tubes—Liquid Phase
C.—Service Tests in Oil Reaction Chambers—Liquid Phase
D.—Hydrogen Sulphide Tests—168 Hours at 850° F.
E.—Oxidation Test—6 Weeks at 1275° F.

Archer continues "Corrosion resistance was estimated at from 4 to 10 times that of ordinary steel while resistance to oxidation was determined to be about three times that of low carbon steel.—The chromium served to increase the strength at elevated temperatures." You will notice this action in Fig. 2.

Having had this same experience in the field learning the hard way, by trial, and not having the facilities of laboratory, clinical and experimental applications on an extended scale, we are glad to know that our own

experience if fully backed up by Archer's experiments on a large number of typical examples.

Without direct quotes we will now give you technical data included in his article and backed by laboratory experiments and, always, by field trials.

Thousands of tons of low-chromium alloy metal were introduced into the refineries and brought much detailed information. Long-time operations at high temperatures upheld early investigations. However, every now and then a tube would be found split after the cleaning operation. It was found that the low impact strength of the liner was the reason. Long service at high temperatures made the steel brittle at a low temperature. The impact of the cleaning tool fractured the tube. Preheating the tube eliminated the cracking danger. However, this was not a real remedy—a new answer appeared.

Five per cent chromium steel with 0.5% of molybdenum or 1.0% of tungsten was tried and cracked tubes disappeared. In the laboratory the steels bearing molybdenum proved superior—in the field no difference could be seen, *no weakness* showed up in either. Therefore the cost must be the determining factor, hence almost all tubes are now made from the molybdenum variety of steel.

Table 1 gives an analysis of a typical chromium-molybdenum steel, while Table 2 shows its quick tensile properties. In Table 3 is shown its allowable creep stress.

One advantage of the molybdenum alloy is the increase permitted in maximum operating temperature. Ordinary 5% chromium steel was restricted to a maximum operating temperature of 1100° F. while molybdenum added raised the upper limit to 1200° F., besides giving added impact strength.

Table 1—Analysis of a Typical 5 Per Cent Chromium-Molybdenum Steel

	Per Cent
Carbon, max.	0.15
Manganese, max.	0.50
Silicon, max.	0.50
Phosphorus, max.	0.03
Sulphur, max.	0.03
Chromium	4.00–6.00
Molybdenum	0.45–0.65

Table 2—Quick Tensile Properties of 5 Per Cent Chromium-Molybdenum Steel

Testing Temperature, ° F.	Tensile Strength, Psi	Elongation % in 2 In.	Reduction of Area, %
Room	75,950	33.5	69.3
800	60,500	28.5	66.8
900	53,350	36.5	73.9
1000	45,350	46.0	83.2
1100	31,700	60.0	90.2
1200	24,450	69.5	93.7
1300	17,800	78.5	96.6
1400	11,370	78.0	98.8
1500	11,890	22.5	73.5
1600	12,940	41.5	50.2
1700	9,950	41.5	49.5

Table 3—Allowable Creep Stress of 5 Per Cent Chromium-Molybdenum Steel

Testing Temperature, ° F.	Creep Stress in Psi	
	0.10%/1000 Hr.	0.01%/1000 Hr.
900	15,250	11,500
1000	10,100	7,600
1100	5,850	3,200
1200	2,800	1,700

It was found that the low-chromium alloys were readily weldable under proper procedure control. In welding 5% chromium steel, as in welding any other material, the deposition of quality weld metal should be as near the properties of the base metal as is possible. When the higher cost alloy is brought into the picture, the need for greater care in fabrication may be appreciated.

The hardest difficulty encountered in successful welding is the air-hardening tendency of the material. "Chromium forces the heat-affected zone, and sometimes the weld metal, into a hard and brittle condition as a result of the thermal and metallurgical changes encountered in the welding operation." Preheating is indicated. Whereas alloys should usually be preheated to *no more* than 400° F., chromium alloys require higher temperatures, not less than 400° F. or more than 500° F.

A metallurgical dodge has been developed to avoid this air-hardening tendency. By the use of elements having a greater affinity for carbon than chromium has, the air-hardening tendency may be materially reduced, or even removed. Columbium, tantalum and titanium have all been successfully used for this purpose, but columbium has been employed the most extensively.

In arc welding the selection of the proper electrode is of the utmost importance. Not only must the deposited metal possess the desired chemical and physical properties but also the electrode must be capable of easy manipulation. Chapman and Moses point out five important characteristics of the electrode. These are "(1) analysis of the bare rod; (2) fluxing qualities of the coating; (3) difference in analysis between the rod and deposited metal due to loss of chromium and other elements and possible gain in carbon and nitrogen; (4) ease of manipulation and physical characteristics of the bead, such as tendency to undercut or to form smooth fillets; (5) the homogeneity of the deposited metal as regards porosity or other inclusions." Welding practices call for the completion of welds and subsequent annealing as soon after welding as possible. This annealing and testing of the material is a long, difficult process.

Now the columbium-bearing non-air-hardening steels will be examined. Columbium is reported to be more efficacious than titanium in retaining the impact strength and toughness of 5% chromium steel at low temperatures, and although high temperatures are encountered still the low-temperature impact strength is retained. Columbium makes the steel able to withstand all normal fabrication operations without developing any hard or brittle areas in the event that the steel is cooled too rapidly. So no danger will be encountered in low-temperature cleaning of columbium-bearing tubes; in addition, the columbium enhances the oxidation resistance, and also improves the resistance to creep.

The selection of columbium-bearing steel obviates the expensive heat treatment necessary when this method is not used, and is economically sound; also some pressure units cannot be annealed after welding.

Notwithstanding *all* these advantages the principal reason for the addition of columbium is its reduction of air-hardening tendencies during welding. Of course where suitable means are available for preheating and annealing of simple chromium alloys, welds may be accomplished; the risk of cracks is, however, always present.

Low-chromium materials may be welded to mild steel. For this purpose if mild-steel electrodes are used, less than 2% chromium develops in the weld, and this method depletes the side wall of some of its chromium.

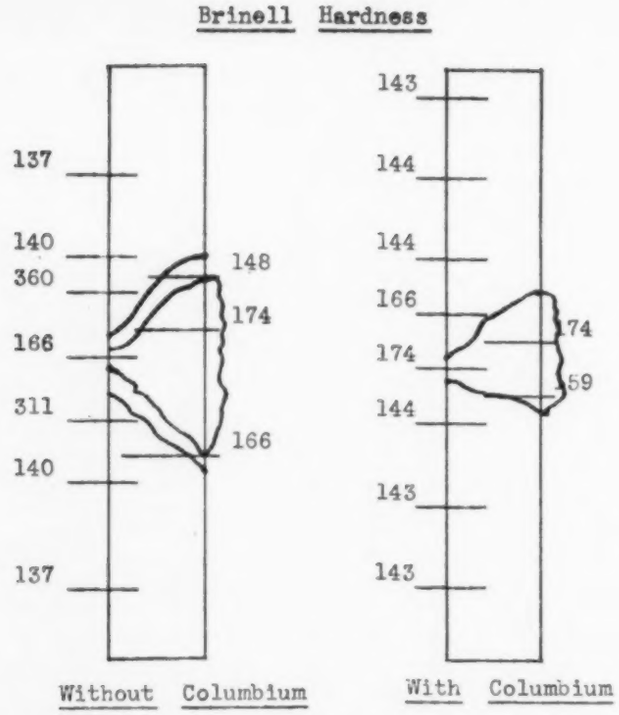

Fig. 3

Five per cent chromium electrodes provide less dilution in the welded joint. But the austenitic types of electrodes lead to less air hardening and provide a joint with excellent resistance to corrosion due to their high chromium content.

Figure 3 shows a welded joint in $^1/_2$-in. plate where the combination of columbium-bearing 5% chromium steel and 24–12 welding electrodes combined—"to eliminate any hard heat-affected zone whatsoever. Ordinary molybdenum-bearing 4 to 6% chromium steel welded with the same electrode showed a Brinell hardness of 300 and 311, respectively, on either side of the weld. This compares unfavorably with the Brinell of 166 and 174 of the weld metal and the 137 of the plate material. Meanwhile the same steel with columbium added showed no zone higher than the 174 of the weld and gradually became lower until the 143 of the plate material was reached. Had an electrode of the 5% chromium type been used the hardened zone of the metal without columbium would have been even harder."

Another stainless alloy, 11 to 13% chromium, has proved to be satisfactory providing the carbon content does not run over 0.08. The later relining jobs have been done with strips 3 in. wide by 30 in. long, welded vertically to the wall of the tower. This method is satisfactory providing at least $^1/_4$-in. space is left between the strips, and welded with three beads, which insures a perfect bond from liner strip to wall of tower, welding done down hill. The method of applying strip at the 45° angle is advised.

It will be noted that nickel is absent from the steel used in this application. The steel used has a melting range between 2750° and 2790° F., is of martensitic structure and has a thermal expansion slightly less, but approximating that of mild steel.

The best corrosion-resisting properties of the austenitic filler metal and straight chromium base metal cannot be realized when the same heat treatment is given to both. The maximum corrosion-resisting properties of the austenitic steels are best realized by a rapid cool from temperatures higher than 1800° F. This is the method employed in welding with the arc, heating to 2750° F., and rather rapid cooling. However, the ferritic class of chromium steels above 20% chromium is not hardened by this treatment. So to eliminate that tendency to harden, the preferable rod to use in welding would be one containing 25% chromium—such as certain 25–20 stainless electrodes. It will be noted that in this instance a stabilizing agent is not employed.

In the past the temperature and rate of cooling of towers, by the various oil companies, have been more or less on a standard set up by the individual company. In the future more importance should be laid on this particular point to prevent excess belling of the stainless lining strip. This belling has occurred too frequently in the past as the result of too rapid cooling. Cooling should be much slower.

Just as much importance should be laid on the bringing of towers up to operating temperature—the rate must be slowed down. Normally on a tower, in which 25 to 40% of the original wall thickness has been corroded away, the operating temperature is about 900° F. and the working pressure around 450 pounds.

In conclusion we may say that for relining towers—

1. A low-chromium-bearing steel is desirable.
2. Molybdenum should be added.
3. A stabilizing agent such as columbium should be present.

That these same factors should be present in the electrode so as not to deplete the parent metal. The suggested new method of installation, at 45° angle, should help on creep strength and breakage.

Or we should use the new steels developed in the 11 to 13% chromium alloys with a high chromium content welding electrode, in which case a stabilizing agent is not necessary. However, the placing of strip at the 45° angle is still recommended.

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The Welding of Stainless Steel*

By H. C. Esgar†

THE subject of welding stainless steels is of such breadth that perhaps a short résumé of the history of stainless steel and a general classification of the stainless steels may serve to clarify a brief discussion of the subject.

As early as 1905 Ellwood Haynes of Indianapolis used cobalt and nickel combined with chromium as a material for spark-plug construction. In 1910 Benno Strauss at Essen combined chromium and nickel with iron in his search for a suitable material from which to make pyrometer tubes. In 1912 Harry Brearley in Sheffield combined iron and chromium in his search for an improved gun lining material. In 1914 P. A. E. Armstrong in Watervliet accidentally introduced silicon into a crucible of chromium steel. The cutlery grade or relatively high carbon straight chromium steels were first commercially developed in 1914. The Krupp patents covering the early chromium nickel steels were first applied for in 1912 and the first fabricated units of this material were shown in 1914. This extremely brief history indicates that the growth of the use of stainless steel coincides rather remarkably with the growth of an extremely important method of equipment fabrication in this country, namely, welding.

Stainless steels may quite broadly be divided into three general groups: (1) austenitic, (2) ferritic, (3) martensitic. While this general classification is quite broad and is based on metallurgical terminology, the steels in any one group are generally similar in properties and the fabricating technique is quite generally the same for all steels in each group.

The austenitic steels may be generally defined as the iron chromium nickel steels, in which the amount of nickel exceeds approximately 7% and a combination of nickel and chromium exceeds about 24%. Small additions of other elements may be found in these steels. This group of steels is normally non-magnetic and cannot be hardened by heat treatment. One of the important characteristics of this group of steels is that they may be materially hardened by cold working, which usually produces slight magnetic properties. In the fully annealed state they possess greater ductility and toughness than ordinary carbon or alloy steels. These steels may be typified by the 18–8, 18–8 stabilized or 25–12 varieties.

The second group, or ferritic steels, are those which contain chromium in excess of about 16%. Nickel is not one of the alloying elements usually found in this group, although small amounts of other elements may be present. This group of steels is only slightly hardened by quenching and may only be moderately hardened by cold working. They have relatively high strength and in the fully annealed condition are quite ductile, although less so than those in the first group. 17 Chrome and 27 Chrome are typical of this group.

The third group, or martensitic steels, are chromium iron alloys containing less than 16% chromium. Very small amounts of other elements may be present. In the fully annealed state, steels in this group are ferritic, but when rapidly cooled from above the critical range they may be quite definitely hardened and are, hence, martensitic. 12 Chrome material is typical of this group.

All of these stainless steels may be welded by any of the usual methods of welding, except forge welding. The rather commonly accepted theory upon which the corrosion resistance of the stainless steels is based indicates that a submicroscopic oxide film forms on the surface of the completely cleaned steel. Unless this film can be completely removed, forge welding is obviously not feasible.

Let us first consider the welding of the austenitic group of stainless steels, which group is the most important from the standpoint of volume produced and fabricated. The welding characteristics of the austenitic steels are dependent upon the physical properties and are quite different from those of ordinary mild steel. The electrical resistance of these steels is about six times that of ordinary mild steel, while the thermal conductivity is only about one-third that of mild steel. These two properties indicate that less electrical energy may be required to produce the proper welding temperature because the losses due to thermal transfer will be reduced. The thermal expansion of these steels is approximately 50% greater than that of mild steel, which property dictates careful thought in design for welding to reduce the possibilities of warping and buckling, as well as internal stresses. The melting range is slightly lower than that of mild steel.

Bearing in mind the fact that stainless steels are usually employed because of their corrosion resistance, care must be exercised in welding to prevent an increase in carbon content of the weld as compared to the parent metal; otherwise, there may be some sacrifice in corrosion resistance. Slag, oxides or foreign particles must be carefully guarded against or reduction in corrosion resistance will be encountered. Sound, ductile welds are readily made by either metal arc or flame methods, but the metal arc is usually preferred because of lower carbon pick-up in the deposited metal. However, the flame method is successfully used with the extremely light gages since accurate temperature control is quite readily possible.

Because of the greater thermal expansion of these steels, careful clamping or jigging should be used and the seam should be tacked at regular intervals. Where heavy work is encountered the "back step" method is frequently employed to avoid excessive heating in any one location.

In all cases of metal arc welding, dry, coated electrodes should be used and the electrodes should be approximately equal to or slightly less in diameter than the thickness of the metal to be welded. Electrodes larger than $^3/_{16}$ in. in diameter should only be used with extreme caution even on the heaviest work. The electrode coatings should be free from all elements that might combine with the deposited metal and alter its composition undesirably. Carbon is the most common offender and for this reason carbon electrodes are not advisable. The metal deposited in the weld should be substantially

* Presented at the February Meeting, Cleveland Section, A. W. S.
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identical in analysis to that of the parent plate. The loss of chromium in welding may be estimated at approximately 1%, which may be disregarded with the higher chromium contents or compensated for by using a filler rod of slightly higher chromium content than the parent plate. Nickel and molybdenum are carried over by the arc with little or no change and manganese and silicon are adequately preserved.

Flame type welds are ordinarily made without filler rod, the flange taking the place of the filler rod. With this type of welding, since the heat will travel further than in the case of the metal arc, the use of chill plates and jigs is desirable. The flame should be maintained as small as possible to avoid excess heat which aggravates the tendency to buckle and warp. An exactly neutral flame is desirable, but since this flame is difficult to maintain, it is advisable to use a slight excess of acetylene to prevent oxidation of the molten metals. If too much acetylene, as manifest by so-called "feather," is used, carburization takes place, making a hard, brittle weld with reduced corrosion resistance. An excess of oxygen produces a porous and unsatisfactory weld through oxidation of the material.

Atomic hydrogen welding is quite useful, particularly for light gage material, and produces a smooth weld requiring a minimum of labor for grinding and polishing. Filler rods are not necessary but may be used if desired with this type of welding. Fluxes are generally not used.

The ferritic stainless steels, or the straight chromium steels, containing more than 16% chromium, are perhaps second in importance to the group just discussed. These steels can be welded by metal arc, flame or atomic hydrogen, but, like the austenitic steels, cannot be forge or hammer welded. The electrical resistance of these steels is high, but the thermal expansion factor is actually slightly less than that of ordinary mild steel. This property reduces the tendency to warp and buckle, but the use of clamping devices and chill bars is still desirable.

These steels may be welded, producing tight welds in so far as fusion and porosity are concerned, but coarse crystalline structures are produced at welding temperatures in the weld deposit and heat-affected zones of the base metal. Welds in these materials are only slightly benefited by annealing and, hence, welded equipment subject to shock or bending stress should be used with caution.

The ductility of the ferritic stainless steels, however, increases with temperature and at temperatures above 400 to 500° F. welded structures may be employed. It is to be noted, however, that if welded structures are maintained in the range of 750 to 1000° F. over long periods of time, ductility will be maintained while hot, but such welded structures are likely to be brittle when cold. Full ductility may be restored by rapid cooling to room temperature from 1400 to 1500° F. In some cases where ductility is required, it is possible to weld the ferritic stainless steels, using weld rods of the austenitic composition, namely, 18–8 or 25–12. Flame welding and atomic hydrogen, as well as arc welding, of these steels are accomplished in much the same manner as that discussed for austenitic steels.

The martensitic steels, or the third general classification of stainless steels, are welded by most methods suitable for mild steel, but, like the two previous groups, cannot be forge or hammer welded.

Tight, sound welds are produced without difficulty, but these steels are susceptible to air hardening; hence the welds in adjacent zones will be very hard and brittle. Preheating and/or suitable annealing following welding will overcome this tendency. The addition of titanium, columbium or aluminum to the martensitic types of steel tend to offset the air-hardening characteristics and are frequently used where high mechanical properties are necessary in equipment fabricated by welding. Referring again to the first and most widely used group of steels, namely, the chromium nickel steels, certain beneficial results are obtained by the addition of titanium or columbium to the parent metal, as well as to the electrode, for the purpose of preventing carbide precipitation and maintaining full corrosion resistance. It is to be noted that in all cases where coated rods are desirable, beneficial results may be obtained by keeping the electrodes thoroughly dry. Most coatings are more or less hygroscopic. If an electrode with a damp coating is used, the moisture is driven off in the form of steam and tends to disrupt the smooth flow of the arc. It is obvious that a dry rod will eliminate this tendency.

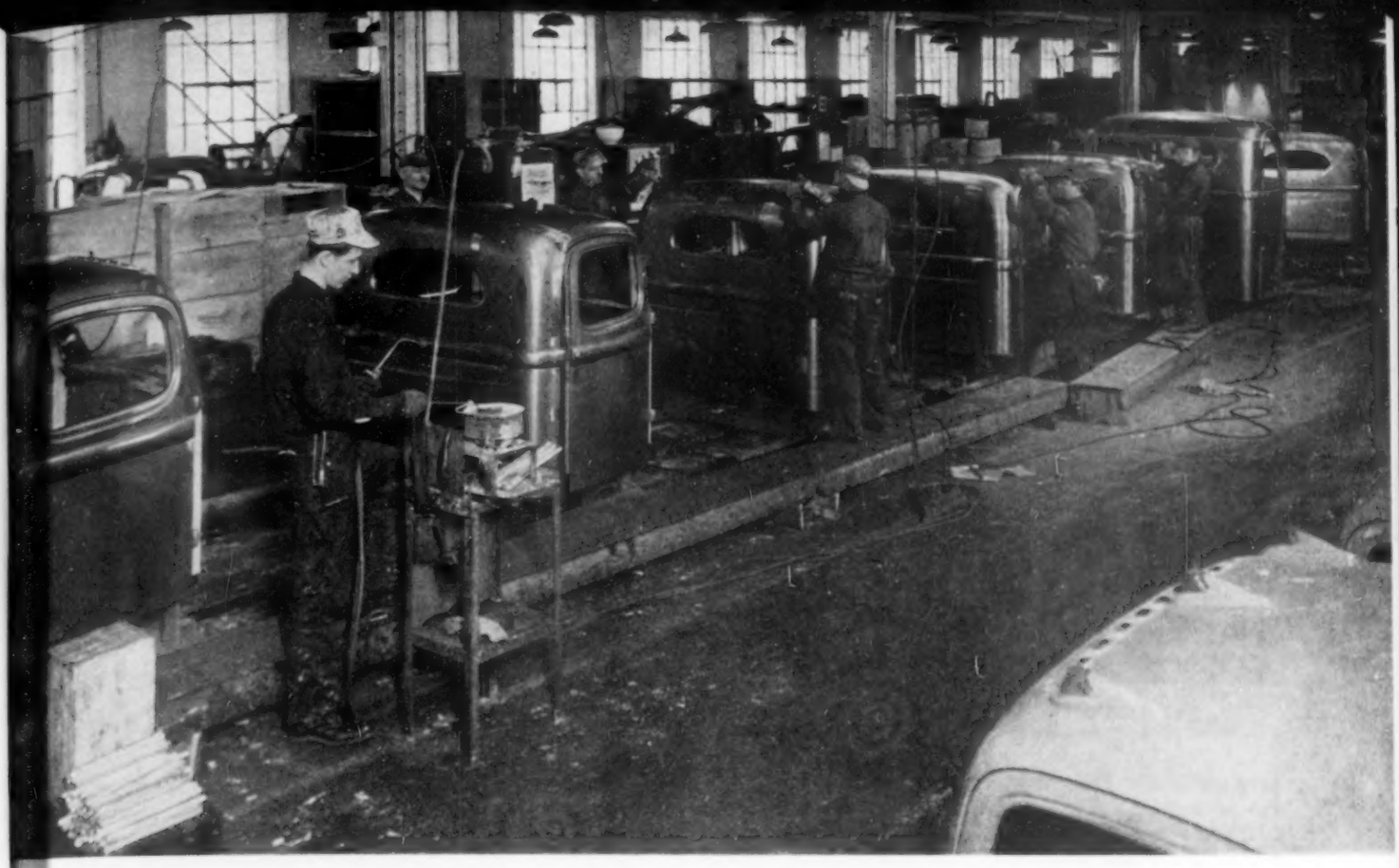
It is believed that most of us are more or less familiar with photo-elastic stress analysis. Such analysis gives a visual picture of the high stress concentrations which may be produced by slag or gas inclusion, as well as by failure on the part of the welding operator to secure complete penetration. A void such as found at the root of a double V weld lacking in complete fusion results in stress concentrations which may account for many of the failures frequently attributed to welding.

Let us consider for a moment the steps encountered in a normal fusion weld. First, we have base metal; second, we have filler rod. In the actual welding operation an electrode or filler rod is deposited in molten form on a molten or semi-molten area of base metal. The completion of the weld involves the inter-reaction of the two portions of molten metal followed by the solidification of the entire mass. Thus, we have two wrought members joined by a cast structure bounded on either side by an area merging from cast to wrought structure.

At this point it is desired to suggest a thought for consideration. There has been considerable recent investigation on the subject of damping properties, and while to the best of our knowledge there has been no particular endeavor to determine the damping characteristics of welded areas, this idea is suggested; namely, is it possible that certain weld failures heretofore explained vaguely, if at all, might not be attributable to a change in damping characteristics of a given structure between the wrought area of the parent metal and the cast structure of the weld? It is conceivable that vibratory stresses originating in the wrought structure could be transmitted to the welded area and at that point be greatly aggravated either through a change in damping characteristics of the cast structure or concentrated at points of undesirable inclusion or even at a point of incomplete penetration at the root area. A search of the existing literature indicates little if any consideration of this problem, and it is suggested that a serious consideration of the problem might reveal data highly informative to the welding fraternity.

Nothing has been said about the welding of high tensile material since the usual fusion methods tend to destroy high tensile properties resulting from cold working. It is, however, possible to weld light gage high-tensile stainless steel by spot welding. For this type of welding, proper control of time, temperature and pressure produce most acceptable welds from a strength and corrosion-resistance standpoint. A modification of this method is that of overlapping spots, which produce acceptable seam welds.

Stainless steel may be used to line mild steel vessels, using the so-called projection or poke method, or by plug welding. We feel that the possibilities of fabrication of stainless steel by welding are limited only by the ingenuity of the designer and the operator.



A Section of the Cab Assembly Line in the Plant of the White Motor Co.

Cab Quality Controlled

By A. Fintz*

HANDCRAFTSMANSHIP is combined with modern tools and the assembly line technique to produce high-quality cabs on a steady production schedule at The White Motor Company plant in Cleveland. Today operations are proceeding smoothly and cabs designed for all Super Power models, including both conventional and cab-over-engine types, are coming off the new line. Only craftsmen of long experience in body building are employed, and extreme care is exercised from start to finish. Emphasis on thorough inspection is apparent from receipt of raw materials to the final seal of approval. A trip along the line will expose something of the manufacturing methods and the quality of cab produced.

To begin with, all parts are fabricated within the plant with the exception of the large steel panels which are made outside with our dies. Except for the preliminary framing operations, accomplished on a major assembly fixture, work is done at various stations along a floor-type chain conveyor line which has a variable speed of from 6 to 18 in. per minute. Cabs are spaced on this line about every 8 feet. Many types of craftsmen are required during the building process including spot welders, arc welders, gas welders, panelers, torch solderers, metal finishers, door hangers, painters, fit-out men and trimmers.

All panels, with the exception of flooring, are of 18-gage steel. The incoming material is inspected according to predetermined standards, and finished according to specifications.

* Manager, Cab Division, White Motor Co., Cleveland, Ohio.

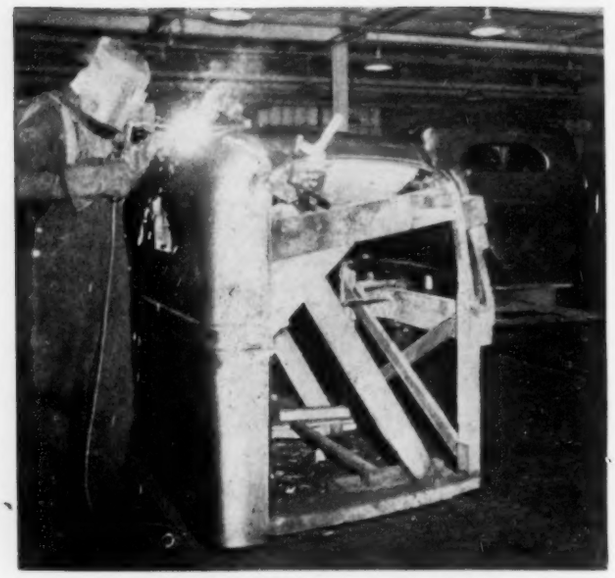
At the first point of assembly, the upper and lower back panels are combined by spot welding along the flanges at close intervals. Two men work together, positioning the unit and operating the foot pedal of the resistance welder.

At the second assembly station, the roof panel and windshield panels are combined by gas welding all the way across. This is done over a special form jig.

At the third assembly point, the completed roof and back panel unit are placed in a major assembly fixture and combined by arc welding, a welder and helper working together. Here, too, the cab shell is attached to the skeleton framework by arc welding, and the all-steel understructure is likewise combined by welding. The understructure itself is made of a 16-gage panel welded to $^1/_8$-in. channel supports. The floor panel is a one-piece stamping made at the plant and fully insulated underneath with $^1/_2$-in. wool for protection of cab occupants against heat or cold.

After these framing operations the cabs go onto the conveyor line. They are torch soldered to fill all seams, one man working on each side. The cabs are then completely metal finished, using sanding belt, disk wheel and hand sandpaper. No putty whatever is employed. The cabs are washed with acid and thinner, preparing the metal for the paint, with full assurance that no rust will eat through later.

Patented Floating Ride seats are installed, one on each side. The seat frames are constructed of tubular rail steel, centrally suspended above the cab floor on heavy alloy-steel coil springs which eliminate the jar of



Welding Roof Panels to the Rear Panels

rough road surfaces. The frames are given one coat of prime and one of enamel. Each frame is supported by two steel arms, known as "ride controls," attached to the rear cab support, and mounted on rubber bushings which act as shock absorbers to control and prevent excessive bouncing. The tension of these bushings can be regulated to meet the weight of each individual driver, thus providing tailored comfort. The seat frames are also fastened to the cab uprights by shackles to hold the seat in a vertical position. This construction gives the entire seat assembly a cradle effect, which smooths out the ride for the driver. To further improve the riding qualities, regular shock absorbers are installed.

Particular pains are taken in hanging the doors, to make them decidedly serviceable as well as nice in appearance. They are thoroughly tested to see that the door action is free. In fact, they must be as easy to operate as the doors of a passenger car.

After a thorough cleaning, the cabs go to the prime spray booth for three successive coats of prime on the outside and one on the interior. Thence the conveyor line takes them through an oven where they are baked for 50 minutes at 225° F.

After the baking the cabs are sanded to a satin finish. The conveyor line then makes a horseshoe turn and brings the cabs back through a finish spray booth, where they are given three coats of finish enamel, and through the other side of the oven where they are again baked for 50 minutes at 225°.

As the cabs come from the final baking, one man installs the windshield while others install the hardware, inside door panels, moldings, glass, upholstery and lining. The windshield is set in dumdum with rubber molding overlapping for full seal. Tubular rubber lace is employed all around the door to keep the draft out, and the door itself is rimmed with rubber strip to insure against air and moisture. All cabs are water tested.

Cabs are air conditioned, employing a roof-type air intake and exhaust system, and two adjustable ventilators in the front panel. Through these two inside doors the air flow is easily regulated. On COE models there is a cowl corner ventilator in addition to the roof ventilator.

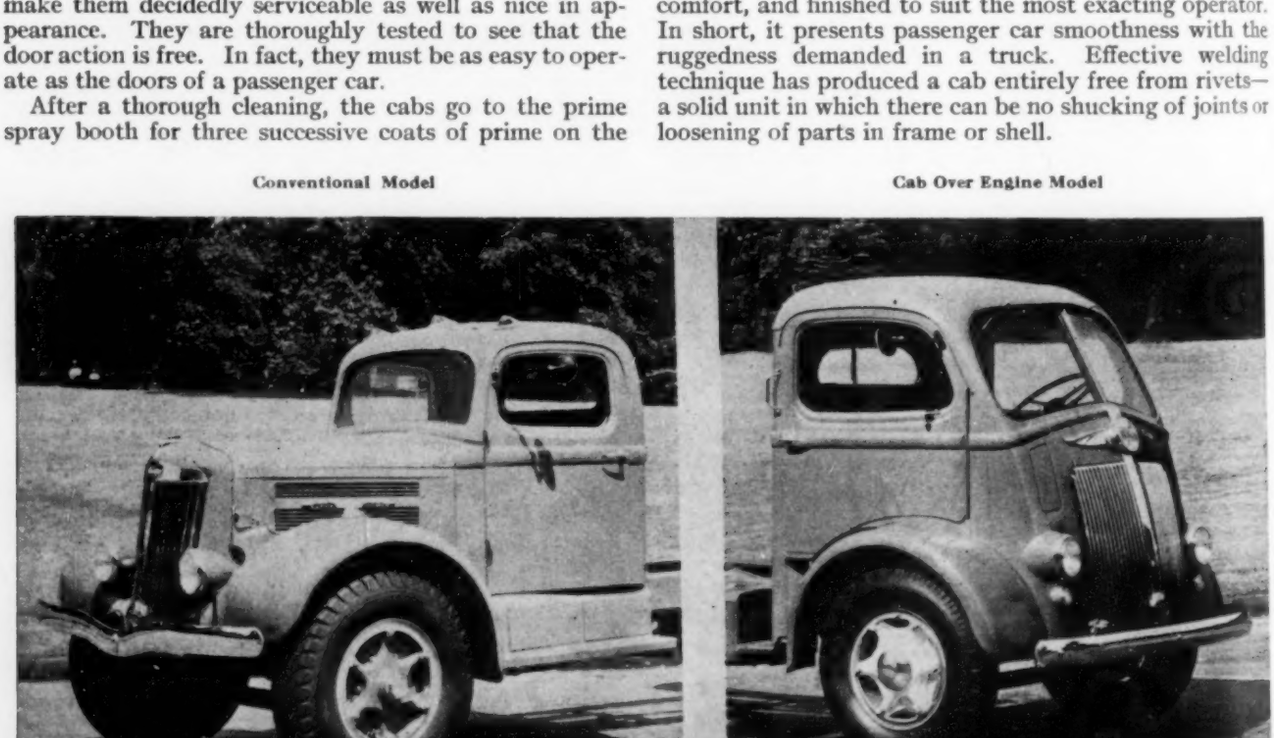
Cabs for Super Power engine jobs, as above described, are strongly welded and entirely free from rivets. The manufacturing procedure by which they are made has proved efficient.

Approximately 22 man-hours are required for the production of a conventional cab, including fabrication of the various parts. The ratio of production is about 7 conventional type cabs to 1 COE. Production, of course, varies with the number of men and the speed of the line. Close control is exercised and not over 30 cabs are ever between the end of the cab line and the point of usage at the chassis erection line. At the present time a cab is produced every seven minutes ready for installation on the chassis.

Regardless of the specification variations, it may be said that the completed cab is a streamlined job, fully insulated against heat, cold and noise, air conditioned for comfort, and finished to suit the most exacting operator. In short, it presents passenger car smoothness with the ruggedness demanded in a truck. Effective welding technique has produced a cab entirely free from rivets—a solid unit in which there can be no shucking of joints or loosening of parts in frame or shell.

Conventional Model

Cab Over Engine Model



Welding Metallurgy

VOLUME II

By O. H. HENRY and G. E. CLAUSSEN

A series of lectures prepared for presentation in a fundamental course of metallurgy and metallography at Polytechnic Institute of Brooklyn under the joint auspices of the Institute and the New York Section of the AMERICAN WELDING SOCIETY. To be published serially in The Welding Journal. The lectures are reproduced in attractive booklet form, copiously illustrated—357 pages—with imitation black leather covers. Volume 1 consists of the first series of 10 lectures given by the New York Section in cooperation with the Polytechnic Institute of Brooklyn last year. Volume 2 includes the series of lectures given this year. The price of the book containing both volumes is $1.50 per copy. Special prices can be arranged for quantity lots of 50 or more.

Part IV—Shrinkage

The local rise and fall in temperature at any point along a weld as the flame first advances toward the point, passes it and retreats, causes distortion and shrinkage stresses as well as the cooling rates and changes in structure that we have studied in the preceding sections. Since distortions are related particularly to hot cracks and since shrinkage stresses are a primary cause of cold cracks, both should be understood to appreciate their metallurgical consequences. Distortion is the change in shape, temporary or permanent, of the welded part as a result of welding. Shrinkage stresses, we shall see, differ in no way from stress (load per unit area of cross section) due to applied loads in service. The atoms of the steel crystals under stress are farther apart (tension) or closer together (compression) than under stress-free conditions, whether the stress is due to shrinkage or to external load. We may have pronounced distortion without appreciable shrinkage stress, as in most sheet metal welding, or we may have practically no distortion but severe shrinkage stress, as in fillet welding thick, clamped plates. The following discussion of shrinkage and expansion shows how distortion and shrinkage stresses occur under simplified conditions. With the fundamentals in mind, the distortions and stresses that occur in welding are explained so far as possible. The discussion closes with a statement of some of the effects of shrinkage stresses on welded parts.

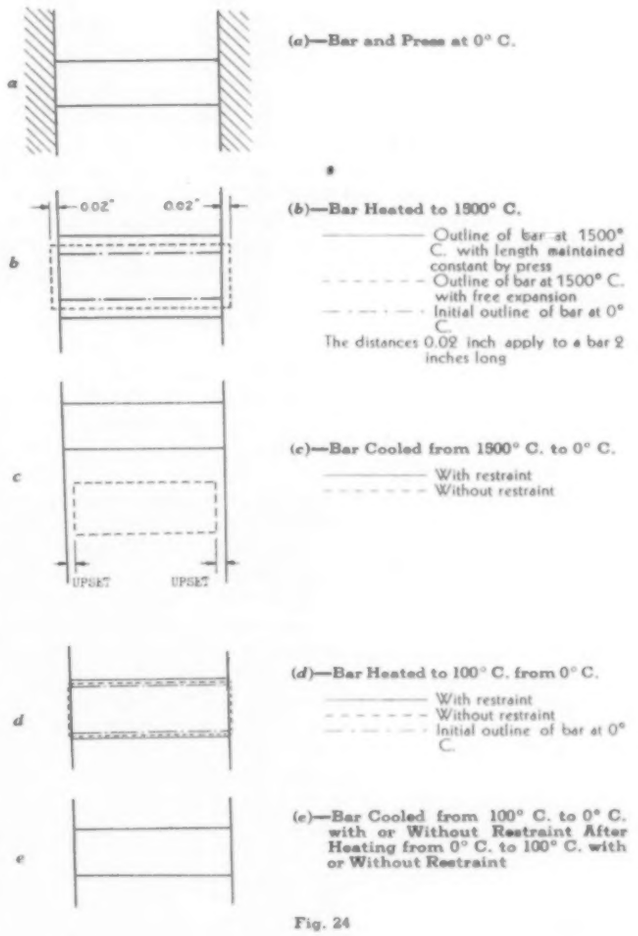

a
(a)—Bar and Press at 0° C.
b
0.02"
0.02"
(b)—Bar Heated to 1500° C.
Outline of bar at 1500° C. with length maintained constant by press
Outline of bar at 1500° C. with free expansion
Initial outline of bar at 0° C.
The distances 0.02 inch apply to a bar 2 inches long
c
UPSET
UPSET
(c)—Bar Cooled from 1500° C. to 0° C.
With restraint
Without restraint
d
(d)—Bar Heated to 100° C. from 0° C.
With restraint
Without restraint
Initial outline of bar at 0° C.
e
(e)—Bar Cooled from 100° C. to 0° C. with or Without Restraint After Heating from 0° C. to 100° C. with or Without Restraint

Fig. 24

Distortion and shrinkage stresses would be non-existent if the metals we welded had zero coefficient of expansion. Actually, every metal expands and contracts when heated and cooled. Temperature changes cause a change in volume, provided the body is not restrained or prevented from changing its dimensions as the temperature changes. Instead of a change in volume, we generally speak for simplicity of a change in one dimension only. The change in one dimension, length, of steel during heating and cooling is shown in Fig. 14. When we say that steel at room temperature has a coefficient of expansion of 12×10^{-6} per degree Centigrade at room temperature, we mean that a 1-inch length increases to 1.000012 inch if the temperature is raised 1° C. and the body is free to expand in all directions. Since, in welding, the parts are never free to expand or contract in all directions, we will study the be-

havior of steel attempting to expand and contract under conditions of restraint.

BAR ANALOGY

A simple condition of restraint is shown in Fig. 24 (*a*), in which the bar of steel under consideration is clamped between the jaws of a press whose distance apart is maintained the same at all times. The press restrains the bar from expanding in much the same way as the metal around a small, heated spot on the edge of a long thick plate is restrained by the remainder of the plate. Heat the bar uniformly to 1500° C. If the press did not restrain the bar from expanding in all directions, the bar, if initially 1 inch long, would be approximately 0.02 inch longer at 1500° C. than at room temperature. Its diameter likewise would increase. When the press restrains the increase in length, Fig. 24 (*b*), the diameter increases an additional amount, to make the volume of the bar at 1500° C. practically the same under restraint as without restraint.

Let us investigate more closely the behavior of the bar while it is being heated. When the 1 inch bar is heated 1° C. it increases in length 0.000012 inch, Fig. 25. To compress the bar to its original length of 1.000000 inch requires the application of a compressive load, which can be calculated from Young's Modulus. Young's Modulus is a physical constant for iron in the same class as density, resistivity and other physical constants. Young's Modulus signifies that each pound per square inch of stress applied to a 1-inch cube in one direction changes the length in that direction by 1/30,000,000 = 0.000000033 inch. The change in length will be a decrease if the stress is compressive; an increase if the stress is tensile. To compress the bar from a length of 1.000012 in. back to 1.000000 in. therefore requires a compressive stress of 0.000012/0.000000033, which we shall call approximately 400 lb./in.^{2} in view of the fact that the coefficient of expansion rises with increase in temperature being nearly zero for steel close to absolute zero, and rising to 15 × 10^{-6} at 400° C.

These computations show that for every degree Centigrade rise in temperature of the bar restrained by the press, a compressive stress of 400 lb./in.^{2} is added to the steel. At first sight it would appear that if we raised the temperature to 1500° C., the compressive stress would be 600,000 lb./in.^{2} Of course, such values never are attained for two reasons.

First, as we continue to compress or elongate a bar of steel, the stress continues to rise until a stress called the yield strength is reached; further elongation beyond the value corresponding to the yield strength or yield stress occurs at nearly constant stress, namely: the yield stress. The yield strength for the restrained bar is, let us say, 40,000 lb./in.^{2} It is obvious that, if we raise the temperature 100° C. (from 0 to 100° C.), the compressive stress in the bar will be 400 × 100 = 40,000 lb./in.^{2}, the yield strength. If we continue to raise the temperature, the stress will not rise. Instead, the stress will remain nearly constant at the yield value, while the steel undergoes permanent deformation.

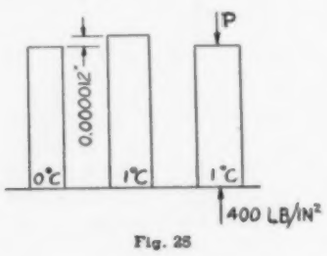


Fig. 25

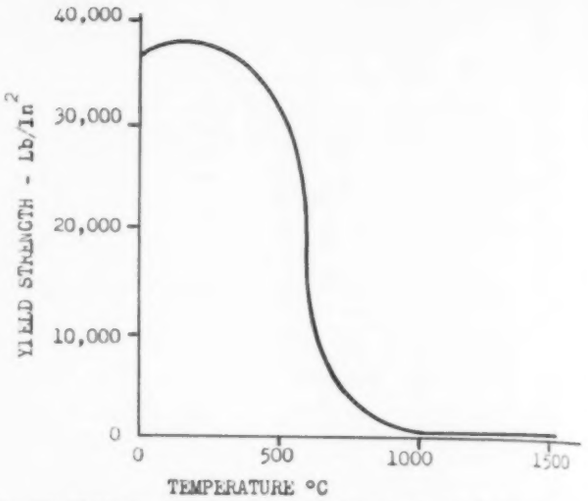


Fig. 26—Yield Strength in Tension or Compression at Different Temperatures

The curve is typical for mild steels, but is schematic. There is a different curve for every metal. At the higher temperatures the curve does not take into account the creep of the steel. The shorter the time of test, the higher the yield strength appears to be at the higher temperatures (above 400° C., Jenkins and Mellor). During welding the steel is not long at the elevated temperatures; hence the short-time yield strength is applicable

The second reason is that at higher temperatures the yield strength of steel decreases, until above about 500° C. the yield strength vanishes altogether, Fig. 26. This is merely another way of stating that we can stretch or twist a red hot bar of steel with a pair of tongs, whereas in the cold we can make little impression on it.

The significance of the two reasons is made clear in Fig. 24. In Fig. 24 (*d*) the bar has been heated from 0 to 100° C. with and without restraint. At 100° C. the bar under restraint has a compressive stress of 40,000 lb./in.^{2}; it is at the yield stress but no permanent compression has occurred. Upon cooling to 0° C. again, the bar returns to its original shape regardless of whether it was or was not restrained during heating and cooling. If the bar is heated above 100° C., for example to 1500° C., Fig 24 (*c*), it makes a great difference whether it has been restrained during heating and cooling. If it has been restrained from elongating during heating and restrained from contracting during cooling, it returns to its original dimension. If, on the other hand, it is restrained during heating, but is allowed to contract freely during cooling, the bar will be shorter and squattier than initially. The bar is said to have been permanently "upset."

Before proceeding further, let us plot the change in compressive stress in the bar that is heated under restraint. As shown in Fig. 27 (*a*), as the temperature of the bar rises, the compressive stress rises. At 100° C. the stress is at the yield value. If the bar is cooled to 0° C. again, the stress decreases along the same path as it increased. There has been no permanent compression; therefore, the bar is free from stress when it reaches 0° C. Had we continued to raise the temperature beyond 100° C., Fig. 27 (*b*), the stress in the bar would have remained at the yield value at all times. At higher temperatures the yield value would have fallen to zero in accordance with Fig. 26, and at 1500° C. far from being under compressive stress, the bar probably would sag under its own weight from the jaws of the press, as thin sheet metal sometimes sags close to a slow weld, if it is unsupported.

HOW SHRINKAGE STRESSES ARISE

We are now ready to return to a discussion of events during cooling. Heating from 0° to any temperature

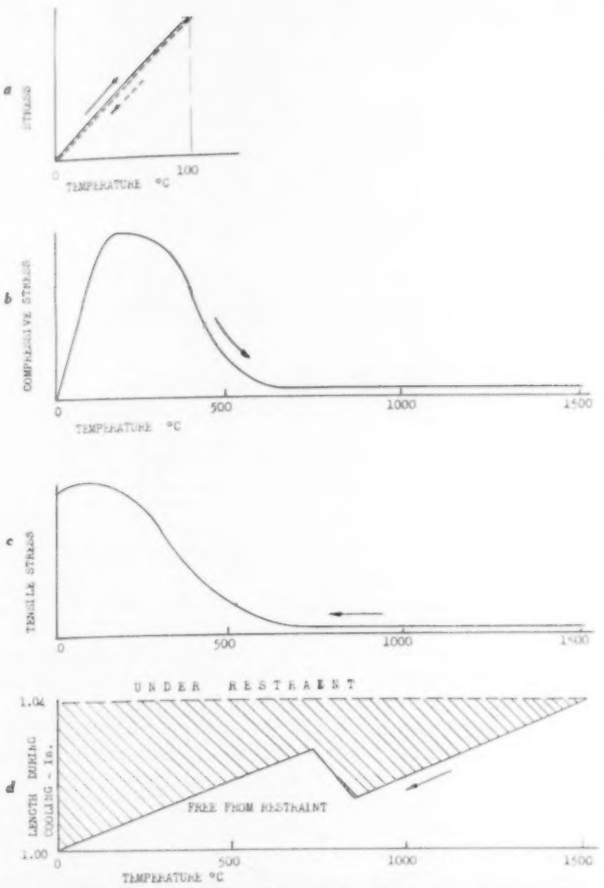


Fig. 27 (*a*)—Compressive Stress Created by Heating to 100° C. Under Restraint, Is Removed Entirely During Subsequent Cooling
(*b*)—Change in Compressive Stress in the Bar During Heating to 1500° C. Under Restraint
(*c*)—Tensile Shrinkage Stress in the Bar During Cooling from 1500° C. Under Restraint
(*d*)—Shrinkage During Cooling from 1500° C.

up to 100° C. and cooling to 0° again with or without restraint left the steel in its original shape without stress, Fig. 27 (*a*). (It will be appreciated that the values 40,000 lb./in.² and 100° C. are selected for illustrative purposes and will differ for different steels.) Cooling under restraint after heating to higher temperatures, such as 1500° C., Fig. 27 (*c*), creates tensile shrinkage stresses.

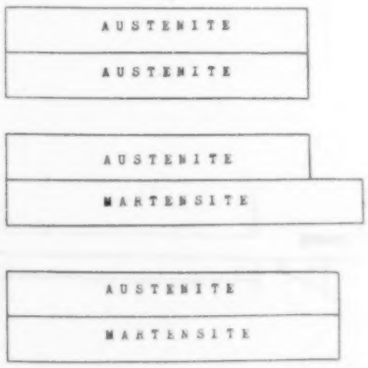


Fig. 27 (*e*)—Shrinkage Stresses in the Vicinity of a Martensite Needle in Austenite

(Upper) A block of austenite, the lower half of which is ready to transform to martensite
(Middle) The lower half of the block has transformed to martensite and its length has increased, assuming no cohesion between austenite and the needle
(Lower) Cohesion being taken into account, both austenite and martensite expand, the austenite being in tension, the martensite in compression

During cooling, the bar, being clamped in the jaws of the press, cannot contract in length; instead the necessary reduction in volume occurs through abnormal reduction in diameter by a hot-working action similar to the extension (reduction in diameter) of a red hot bar by pulling both ends. At about 500° C. the steel commences to regain elastic strength, as shown by the rise in yield strength below 500° C., Fig. 26. Thereupon the steel becomes stressed in the reverse manner to the stress during compression.

For example, in cooling from 500 to 499° C. the steel should shrink 0.000012 in. in length. It is withheld from contracting by the press; in other words, the press must exert a stress of 400 lb./in.² on the steel. (Again the values are illustrative only, Young's Modulus and the coefficient of expansion being different at 500° C. from 0° C.) Further cooling brings the tensile shrinkage stress to the yield value; perhaps it may be at the yield value at all times, depending on the shape of Fig. 26. The stress remains at the yield value thereafter, further changes in length being prevented at the lower temperatures by permanent deformation (cold work at these temperatures). When the bar reaches 0° C., therefore, it has been permanently, if slightly, elongated and is under a tensile stress equal to the yield strength. While the bar remains in the press it has the same dimensions as it did before heating. Upon removal from the press, the bar will contract in length and increase in diameter corresponding to complete release of the shrinkage stress. The change in length of a bar cooled without restraint from 1500° C. is contrasted with the constant length of the restrained bar in Fig. 27 (*d*).

The bar completely restrained in the press during heating and cooling illustrates qualitatively the origin of distortion and shrinkage stresses during welding, for the bar is analogous to a short length of weld metal (tack weld) cooling between clamped plates to be butt welded. It is analogous also to a flash weld or resistance butt weld between two bars held in the clamp after welding. The analogy is not exact because in both examples the temperature is not distributed uniformly. It is to be observed that the shrinkage of a metal during solidification affects the formation of shrinkage cavities and hot tears, but has no direct effect on distortion and shrinkage stresses. A spot weld in thick plates is in a similar situation to a bar of the type we have been considering, if the bar had been restrained in two directions instead of one.

The bar analogy is useful in predicting the effect of preheating on shrinkage stresses and distortion. If the bar initially is at 500° C. instead of 100° C., it is obvious that heating to 1500° C. and cooling to 500° C., again under restraint can give rise to no shrinkage stresses, although distortion will have been undergone. Having scarcely any yield strength at 500° C., a steel part heated to that temperature may sag (distort) under its own weight. If the preheating temperature is only 100° or 200° C., the bar will be under tensile shrinkage stresses equal to the yield strength as if it were not preheated. With preheat temperatures between about 200° and 500° C., the restrained bar will be under tensile shrinkage stresses intermediate between the yield strength at room temperature and zero, which is approximately the value at 500° C.

In addition to shrinkage stresses created by changes in temperature and permanent deformation, shrinkage stresses may arise from transformations in the steel. Any changes in length due to transformations (see caption to Fig. 14 (*b*)) that occur above 500° C. will cause no shrinkage stresses, because the yield strength is low, Fig. 26, and the expansion due to the change

from gamma to alpha is accommodated, if necessary, by permanent elongation, perhaps counterbalancing the contraction due to cooling. However, if the austenite does not transform until nearly room temperature, at which the yield strength is high and creep is negligible, shrinkage stresses may arise. Consider a needle of martensite forming in austenite, Fig. 27 (*e*). The martensite must occupy a greater length than the austenite from which it sprang. It is restrained from expanding by the surrounding untransformed austenite, as we found toward the end of Part II. Consequently the martensite is under high compressive shrinkage stress, whereas the adjacent austenite is under high tensile shrinkage stress. The areas of different shrinkage stresses due to transformation are on a microscopic scale, compared with the larger scale variations of shrinkage stresses due to upset during welding and compared with the variations on a still larger scale created by reaction stresses.

The effect of rate of heating and cooling on the distortion and stresses in the bar also can be predicted. The shorter the time at temperature, the higher the yield strength appears to be in the range 400–600° C. With more rapid heating and cooling, therefore, the amount of cold work that the bar will undergo will increase compared with the amount of hot work. In welding we know that rapid cooling rates are associated, in general, with low heat inputs and narrow heat-affected zones. The narrower the heat-affected zone, for a given type of weld, the less will be the distortion, other conditions being the same.

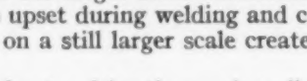


Fig. 28—Bulging (Exaggerated) of Plate on the Reverse Side of Fillet Welds in Plates About 1/16 Inch Thick

The plate became nearly red hot on the reverse side during welding

The upset that is mentioned in Fig. 24 (*c*) can be observed in fillet welds in thin plate, say 1/4 inch, in which the temperature rises nearly to a red heat on the opposite side, Fig. 28. The barely perceptible bulge or upset shows that the metal at the bulge attempted to expand during heating. The surrounding plates prevented the expansion and upset the weak hot metal. During cooling the rigidity was not sufficient to iron out the bulge once it had formed. In any application of the bar analogy to welding distortion it is important to remember that in welding, restraint during heating ordinarily is higher or more rigid than during cooling, the explanation being suggested by Fig. 2.

DISTORTION

There are three classes of shrinkage distortion that are particularly important in welding.

1. Shrinkage Perpendicular to a Butt Weld.—The shrinkage perpendicular to a butt weld depends primarily upon the cross section of the weld, Fig. 29. The larger the cross section the greater is the shrinkage, which can be taken very approximately to be 1/4 inch per square inch of weld cross section. Accordingly the shrinkage perpendicular to the weld will increase with increase in thickness for a given type of joint. Exact values for distortion cannot be given, for it varies with degree of restraint, and extent to which heat flows from weld into plate (thickness, backing, etc.). Properly

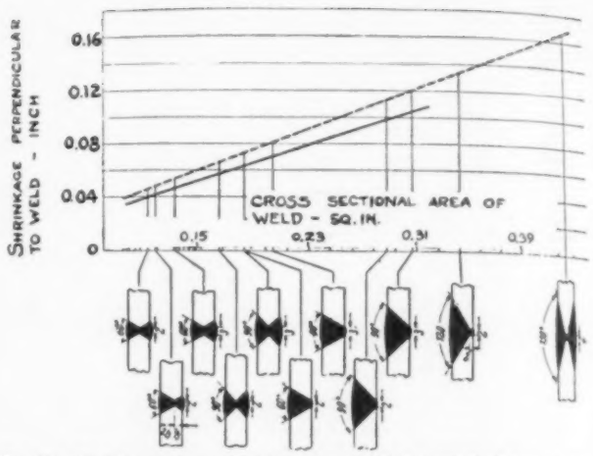


Fig. 29—Shrinkage Perpendicular to the Weld in Welded Butt Joints 0.08 or 0.12-Inch Root Spacing

——————— Arc welding, bare electrodes
- - - - - - - - - - - - - - - - - Arc welding, covered electrodes. (Mallsius)

conducted peening can be relied upon to counteract distortion perpendicular to the weld.

2. Shrinkage Parallel to a Butt Weld.—The shrinkage parallel to a butt weld tends to reduce the width of the plate at the weld. It seems reasonable to believe that the parallel shrinkage will be a fixed percentage of the length. In other words, a weld 2 inches long will shrink twice as much parallel to the weld as a similar weld 1 inch long, whereas both will yield the same shrinkage perpendicular to the weld. The percentage must be determined by trial, for it may vary from 0.05 to 0.5% in different types of welds. Shrinkage parallel to the weld accounts for the bowing of square-edge joints, Fig. 30.

3. Angular Distortion.—Angular distortion is illustrated for V butt and fillet joints in Fig. 31 (*d*). There is a shorter length of contracting weld metal at the root than at the face of each weld, which accounts for the angular distortion. It can be counteracted by using

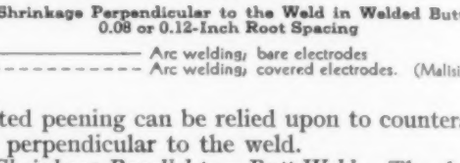


Fig. 30—Edge Weld

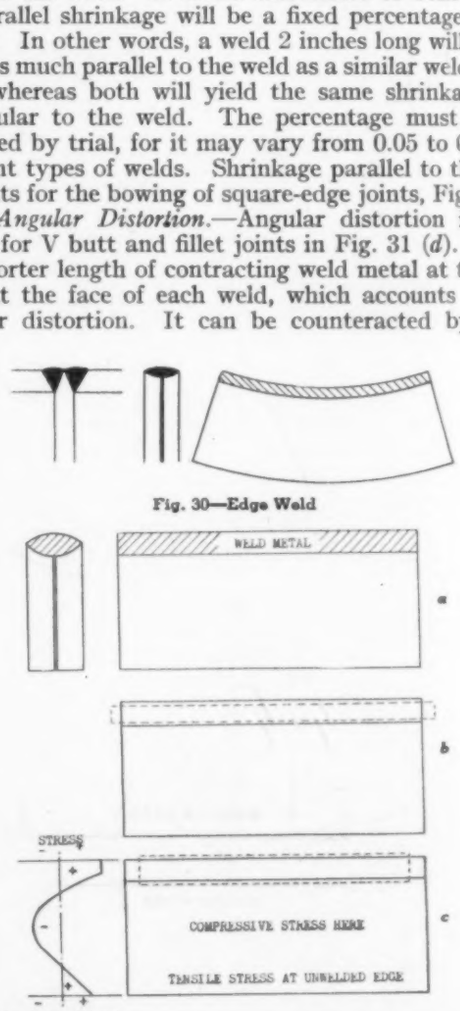


Fig. 31 (*a*)—Edge Weld
(*b*)—Welded Area Endeavors to Expand During Welding, as Shown by the Dotted Outline, but Is Restrained by Adjacent Cooler Metal, and Is Upset
(*c*)—Welded Area Endeavors to Contract During Cooling, as Shown by the Dotted Outline, but Is Restrained by Adjacent Cooler Metal, and Is Elongated.

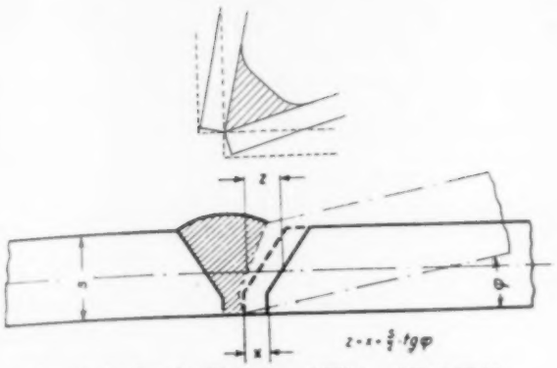


Fig. 31 (*d*)—Angular Distortion of Fillet and Butt Welds

(Upper) Fillet
(Lower) Angular distortion of a butt weld

ϕ = Angular distortion
x = Shrinkage perpendicular to weld without angular distortion
z = Total shrinkage perpendicular to weld

double V butt joints and T fillet joints welded from both sides. In unclamped single-bevel T and butt joints angular distortion is nearly proportional to the number of layers, assuming all layers are of the same size. The angular distortion of an 8-layer 60° V butt weld in $^3/_4$-inch plates may amount to 5° or 10°. Depending on plate thickness and other variables, angular distortion of a V butt weld in thick plate may be decreased by preheating, by weaving the electrode back and forth across the joint 50 or 100 times a minute, and by back-step welding. The best conditions for reducing distortion may be different in the lower layers of a thick weld in which the heat from each bead penetrates through nearly the entire deposit, than in the upper layers during the deposition of which the lower layers remain relatively cool.

In applying the general rules about distortion, another rule is important. Thin sheet often buckles during welding whereas heavy plate does not. The buckling is caused by the well known inability of laterally unsupported sheet to resist compressive stress without buckling (column failure). Compressive shrinkage stress in regions near the weld, as we shall see later, accounts for the buckling. Wandering sequence also is a corrective for distortion. Instead of making all the welds in strict succession, welding alternately on opposite sides of a part often will reduce distortion. The distortion of the weld on the opposite side may neutralize the distortion created by the first weld. When welding is resumed on the first side, furthermore, the temperature has fallen and less of the metal will enter the plastic range during subsequent welding.

SHRINKAGE STRESSES

When we attempt to establish general rules about shrinkage stresses we find that the rules for distortion are of little help. We shall have to start by applying the bar analogy to a simple type of weld, realizing that we do not know enough about shrinkage stresses in more complicated welds to be able to predict their distribution. One general rule, nevertheless, seems to apply to nearly all types of welds, made at room temperature regardless of restraint: the maximum tensile shrinkage stress is close to the yield strength. If the tensile shrinkage stresses act in two or three directions instead of in one direction, the stress at which the metal yields is raised, Fig. 18, and the maximum tensile shrinkage stresses likewise rise to values that may be considerably above the yield strength observed in the tensile test.

The simple weld we shall study is shown in Fig. 31 (*a*). The weld is deposited rapidly so that we can be safe in assuming that the entire welded zone is at a high temperature when the weld is completed. At the high temperature the metal close to the weld tends to expand in all directions. It is prevented (restrained) by adjacent cold metal, which replaces the press in the bar analogy. Being prevented from elongating, the metal close to the weld is upset, Fig. 31 (*b*). During cooling the upset zone tends to contract. Again it is restrained by adjacent cold metal. As a result the upset zone becomes stressed in tension (tensile shrinkage stresses) in the same way as the bar in Figs. 24 (*c*) and 27 (*c*). When the welded joint has cooled to room temperature, the weld and the upset region close to it, Fig. 31 (*c*), are under tensile shrinkage stresses close to the yield strength. To balance the tensile shrinkage stress at the edge, equilibrium conditions demand that there must be a region of tensile shrinkage stress at the opposite unwelded edge, and a region of compressive shrinkage stress between the two tensile zones. These deductions agree in every respect with experimental measurements of the shrinkage stresses.

Although it is not difficult to predict the distribution and magnitude of shrinkage stresses in a joint of the type shown in Fig. 31 (*a*), the problem becomes more difficult with many other types of joint for the reason that the shrinkage stresses are important not only parallel to the weld, but perpendicular to the weld as well. Consequently, we must rely on experimental measurements of shrinkage stresses, remembering only the general rule that the shrinkage stresses are likely to be close to the yield strength if the majority of the welded part during welding was several hundred degrees below the temperature at which the yield strength virtually vanishes; that is, if the weld was made close to room temperature.

The shrinkage stresses measured in a butt weld between two plates are shown in Fig. 32 (*a*). The stresses may be measured by several methods, a reliable method, known as the subdivision method, being illustrated in Fig. 32 (*b*). The shrinkage stresses parallel to the weld are shown in Fig. 32 (*a*) for the central region of the plates. In agreement with predictions, the shrinkage stresses parallel to the butt weld at the center are tensile and are close to the yield strength. Beyond the narrow upset zone near the weld the shrinkage stress falls rapidly to zero and changes to compression as we recede from the weld. The rapid change from tension to compression

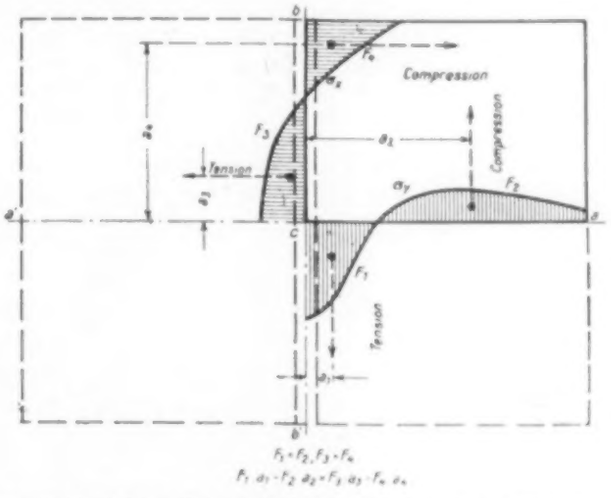


Fig. 32 (*a*)—Relation Between Shrinkage Stresses in Arc-Welded Plates Without Restraint

b–b = Line of weld. (Bierett)

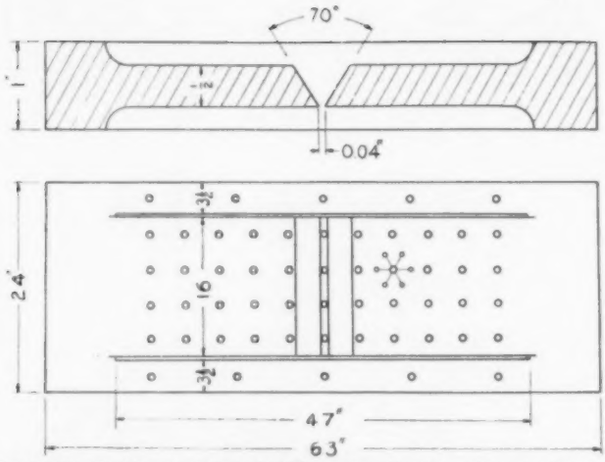


Fig. 32 (*b*)—Subdivision Method of Measuring Shrinkage Stresses Created by a V Butt Weld. (Mies)

Imaginary, equal squares are ruled on the surface of the plates. Gage marks (small circles) are punched at known distances apart on each square. One pair of gage marks in each square may be perpendicular to the weld, the other may be parallel to the weld. The squares are cut from the plate after welding. If the distance between gage marks parallel to the weld increases as a result of cutting, the steel in the square was under compressive shrinkage stress parallel to the weld. If the distance decreases, the steel in the square was under tensile shrinkage stress parallel to the weld. Similar considerations govern stresses perpendicular to the weld. The changes in length are converted to stress by means of established formulas. The release of shrinkage stresses by subdivision (machining) results in distortion

suggests stress gradients, similar in nature to the temperature gradients described in Part I. The stress gradients might be defined as a change in stress of, let us say, 10,000 lb./in.^{2} per inch. However, we know practically nothing about the significance of stress gradients at the present time. It seems that extremely high stress gradients, for example 30,000,000 lb./in.^{2} per inch, have less effect than might be anticipated, because the change in stress must occur in the space of a single grain, which may be able to yield locally. The shrinkage stress parallel to the weld falls to zero at the edges of the plate perpendicular to the weld, because the atoms at the very edge of a plate cannot be stressed perpendicular to the edge, which is in contact with air.

At right angles to the weld the shrinkage stresses are maximum at the weld. Regions some distance from the weld are stressed less highly perpendicular to the weld than the regions close to the weld. Fig. 32 (*a*) shows that in the center of the plate the shrinkage stress at right angles to the weld is tension; the edges are in compression to maintain equilibrium. It is always fortunate to have compressive initial stress at the edges of any part, because the edges are the most sensitive regions of a part from the standpoint of notch effects. The distribution of stresses shown in Fig. 32 (*a*) is not always observed, for step-back procedure or frequent and long interruptions to change electrodes may alter the distribution.

It should be remembered that the plates of the butt weld in Fig. 32 (*a*) were under no restraint whatever during welding. Had the plates been clamped rigidly during welding, additional tensile stresses, known as reaction stresses, would have arisen throughout the plates perpendicular to the weld. The reaction stress, Fig. 33, develops for the same reason as the tensile shrinkage stress in the bar shown in Figs. 24 (*c*) and 27 (*c*). When the butt-welded plates are unclamped, the reaction stresses disappear. Often, however, it is not so simple to avoid or remove reaction stresses, particularly if the weld is the last to be made in a complicated, rigid structure. Under those conditions the reaction stresses rise to a maximum, Fig. 34, and remain in the welded structure, other regions being under compressive stress to maintain equilibrium. Large amounts of weld metal (90° compared with 45° included angle, for instance) favor high reaction stresses; small amounts of weld metal favor low reaction stresses but may give rise to hardness and brittle martensite.

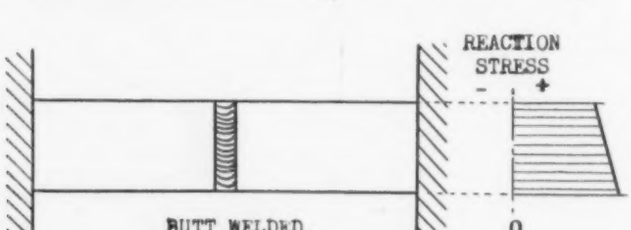


Fig. 33—Reaction Stresses Are Added to the Shrinkage Stresses That Would Have Appeared in Welding the Plates Without Restraint, Provided the Sum of the Two Does Not Exceed the Yield Stress. Otherwise Permanent Deformation Occurs

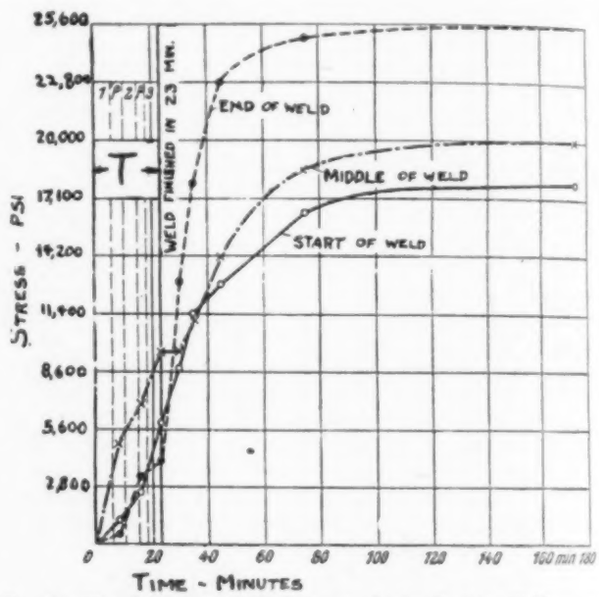


Fig. 34—The Development of Reaction Stress During Welding and Cooling in a Butt Weld Made with Bare Electrodes

The extensometer was located perpendicular to the weld and 9¹/₂ inches therefrom. (Bierett)
1 = First layer; 2 = Second layer; 3 = Third layer; *P* = Pause

Shrinkage stresses are found in fillet welds as well as in butt welds. Fig. 35 shows the shrinkage stress parallel to fillet welds joining the flange to the web of an arc-welded T girder in the vicinity of a butt weld in the web plates. Maximum tensile shrinkage stresses occur at the fillet weld, the bottom of the girder fortunately being in compression as a result of welding. When load is applied to the top of the girder, the bottom tends to be stressed in tension. The initial compressive stress prevents the appearance of tensile stress at the bottom of the girder, which is the most critical region from the standpoint of failure, even when the applied load corresponds to a tensile stress of a high order in the bottom fiber.

The diagrams of Fig. 35 suggest that shrinkage stresses due to welding may have a useful function, besides being a disadvantage in causing cold cracks in hard, heat-affected zones that may occur under incorrect conditions with high-tensile steels of unsuitable hardening characteristics. If the steel is capable of a little permanent deformation without cracking, the shrinkage stresses tend to disappear when excessive loads are applied. In Fig. 36 (*a*) the welded plate has the shrinkage stresses similar to those for the edge weld in Fig. 31 (*c*). For simplicity the stresses have been divided into five zones,

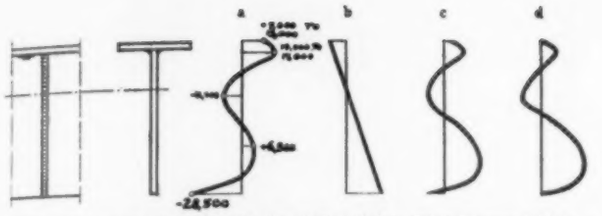


Fig. 35—Shrinkage Stress (in Lb./In.²) Parallel to Web-Flange Welds of Arc-Welded T-Beams at a Butt Weld in the Web. (Bierett)

Flange = 6 × 0.59 in. Web = 11 × 0.39 in. Throat of fillet = 0.16 in.
(a) Shrinkage stress in the butt weld
(b) Bending stress due to external load
(c) Resulting stress due to external load of 20,000 lb./in.² in extreme fiber
(d) Resulting stress due to external load of 28,500 lb./in.² in extreme fiber

X in tension ($+S$ lb./in.²), Y with no stress, and Z with compressive stress ($-S$ lb./in.²). Upon stretching the plate under a high-tensile load, sufficient to elongate the plate by amount A, we find that the shrinkage stresses change, Fig. 36 (*b*). The X zones undergo permanent deformation in elongating, while the stress in the Z zone decreases. The stress in the Y zones rises. Observe that the stress in the X zones does not rise to any appreciable extent. When the load is removed, the X zones contract along the straight line S_1 S_2; the stress in the X zones is S_2 after contracting an amount A equal to the elongation caused by the applied load. Obviously the shrinkage stresses have been decreased by the applied load.

As a general rule, shrinkage stresses are decreased by loads (static or fatigue) sufficient to cause permanent deformation, in other words, by stresses beyond the yield strength. If, due to unfavorable structure or multiaxial stresses, the steel is incapable of undergoing permanent deformation without cracking, the shrinkage stresses may bring the part to premature failure. Shrinkage stresses may be dissipated nearly completely by stress relief heat treatment (see Part VIII).

Questions

1. What is the difference between stress and distortion?
2. A V butt weld is made in free plates 6 x 6 x $^1/_2$-inch thick. Describe the distortions that occur as a result of welding. Where are the maximum tensile shrinkage stresses?
3. How are shrinkage stresses related to yield strength at room and elevated temperatures?

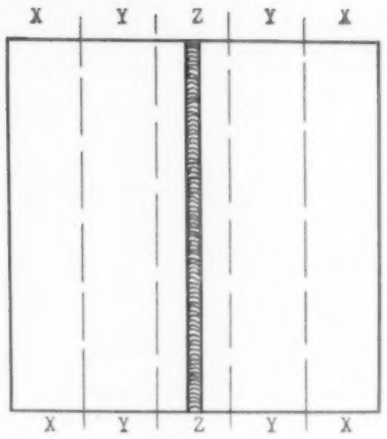


Fig. 36 (*a*)

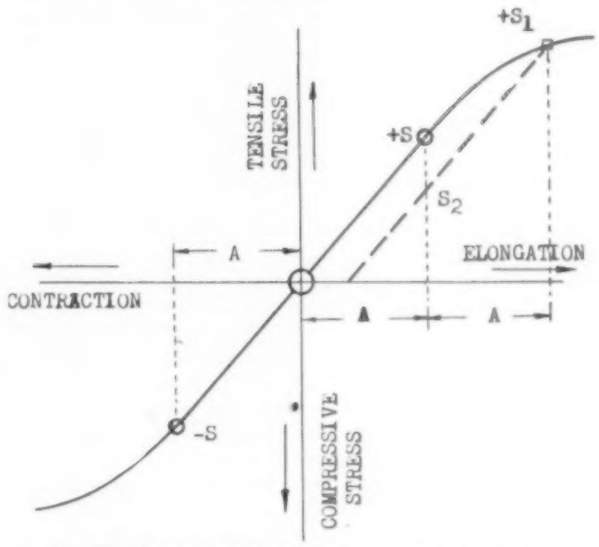


Fig. 36 (*b*)—Release of Shrinkage Stresses by Deformation

4. What is the connection between shrinkage stresses and cooling rate or temperature gradient in a weld?
5. In what way may the transformation of austenite during cooling affect shrinkage stresses in the weld?
6. What is a stress gradient and what is its significance?

Fig. 1

Treasure Island Bridge

By R. E. Spaulding *

THIS electric arc-welded structure on Central Avenue between the City of St. Petersburg and Treasure Island, St. Petersburg, Florida, had all shop work electric arc welded, field connections were partly welded and partly riveted. The reason for this field riveting was that at that time, about two years ago, we had not changed to 100% welding and since there were to be field holes for the fastening up and alignment of the structure before field welding it was decided to fill these field holes with field rivets. Consequently, the bracing system and other secondary connections are all field riveted. All principal connections are welded.

Figure 1 is a general view of the bridge in closed position.

Figures 2 (cover) and 3 are views of bridge in open position.

Figure 4 is a view from under side of one leaf in open position. In this picture can be seen some of the welding details, particularly as to the trunnion shaft and trunnion gear. The trunnion shaft was field welded directly to the girder. The radial gear rack was first field bolted and then field welded to the structural steel

* The Aetna Iron & Steel Co., Jacksonville, Florida.

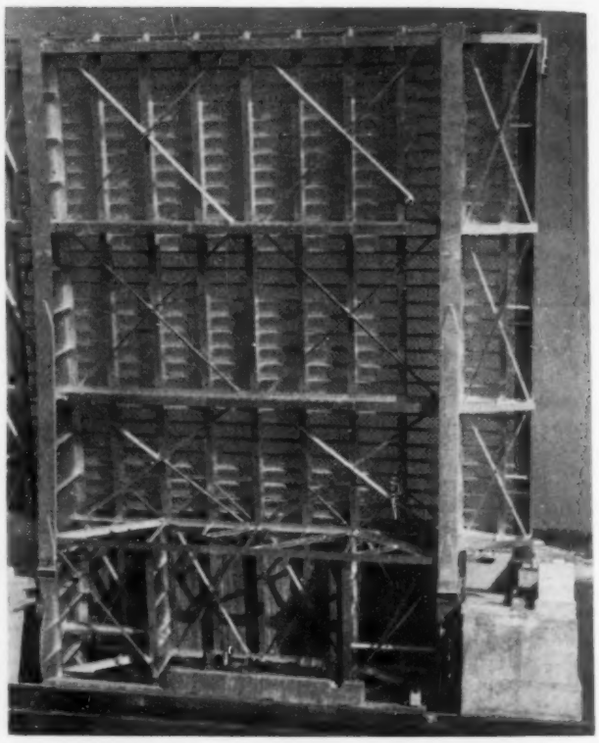
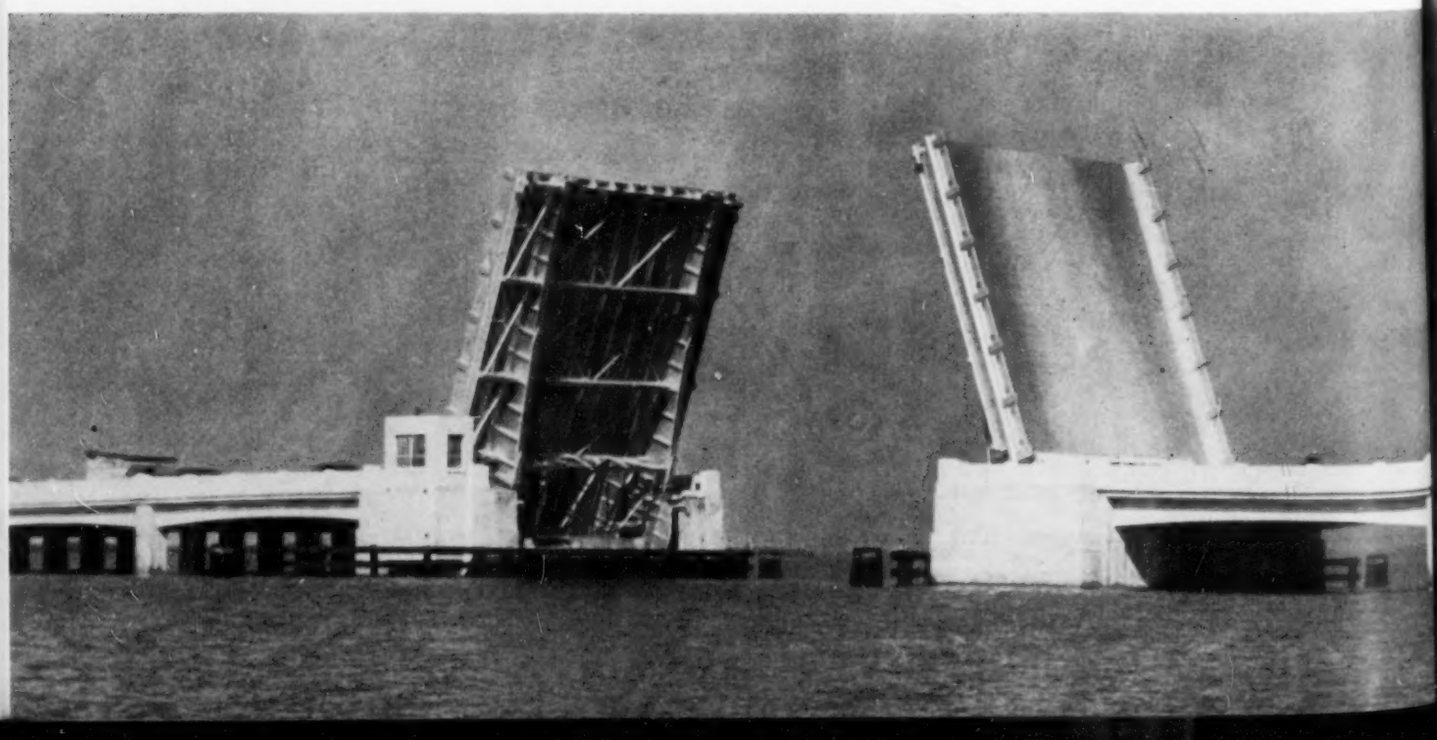


Fig. 3 (Below)

Fig. 4 (Above)



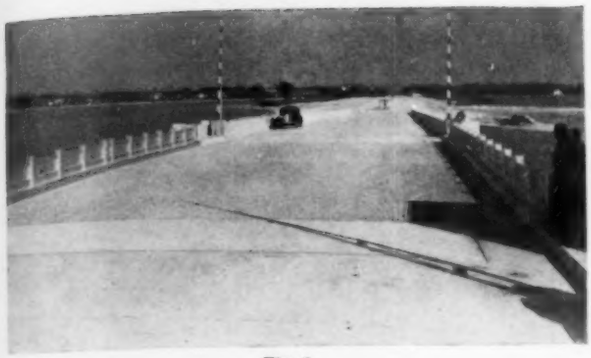


Fig. 5

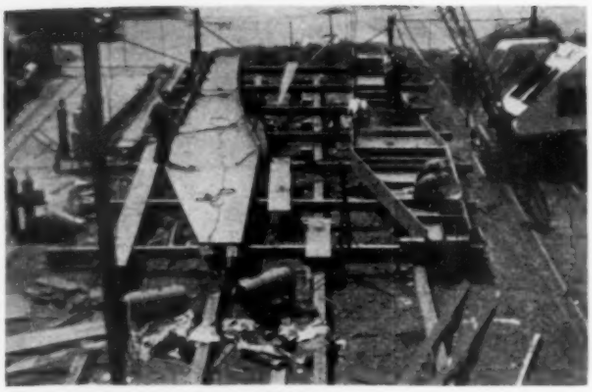


Fig. 6

frames supporting it, thereby eliminating expensive steel castings.

Figure 5 is a general view of roadway which also gives a view of the pressed steel handrailing, entirely field welded, made to correspond to the concrete railing of the approach spans.

Figure 6 shows fabrication of the main girders.

This bridge has been in operation for more than a year without the slightest difficulty being experienced.

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(*Continued from page 287*)

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Welding Society

ACTIVITIES — Related Events

THE PRESIDENT'S MESSAGE

The educational programs of Sections have normally been included under the regular program and special lecture courses. This past year there have become available a new educational factor under the National Defense Training Program. In some cities there have been organized special welding courses under this training program. It may be anticipated that funds will be available for such courses during the next training year and local welding sections might well study the possibility of developing such courses in their communities. The length of such courses and the subject matter covered are extremely flexible and there is an opportunity to train welding engineers or to instruct civil or mechanical engineers in the design of welded structures and the application of welding.

Special lecture courses may be developed by the Section to supplement their normal courses or they may be used for special purposes. In some Sections highly successful courses have been developed more for the purpose of giving mechanical and civil engineers detailed information needed for the application of welding to their designs. The attendance at such courses has been largely made up of non-members of the SOCIETY. Such courses are highly desirable in stimulating wider use of welding.

In special lecture courses it is practicable to cooperate with other organizations in laying out a course. For example, a lecture course based on the properties and use of metals for welding would be of interest both to the welding engineer and to the metallurgical engineer.

During the coming year there will be an increased demand for training in the various National Defense industries. This includes the aircraft, shipbuilding and munitions industries. Some of these industries are developing outside of centers in which Sections of the SOCIETY now exist. Some Sections may render a conspicuous service by organizing sub-sections in such localities.

These suggestions for engineering training have not included any thoughts on operator training. Some Sections have specialized in such training and there will be a greater demand for operator training because of the expansion of the welding industry and the greater use of low-alloy steels and special materials in the National Defense industry.

It would be highly advisable that plans be made during the summer for these training courses. The SOCIETY'S Headquarters staff is available for any services they may render to Sections in working out their plans for the coming year.

SHIPYARD INSPECTORS NEEDED FOR U. S. MARITIME COMMISSION

Ship inspection positions, paying from $2300 to $3800 a year, are open in the Maritime Commission. An examination to secure these inspectors has been announced by the United States Civil Service Commission.

There are hull inspection positions involving shipfitting, welding, tank testing and mold loft work. Machinery inspectors will be concerned with the installation of marine machinery, aligning shaftings, checking clearances, refrigerating machinery and windlasses. The electrical inspectors will inspect the installation of electrical equipment on ships. The inspection of installation and construction of ship joiner work including non-combustible materials will be the job of joiner inspectors.

Applicants for all these positions must show that their experience has included the interpretation of specifications and the making of such computations and accurate measurements as are necessary to determine full compliance of work with plans. Responsible practical experience in ship construction involving the type of work pertinent to the duties of the position applied for is required. Under certain conditions, a partial substitution may be made of college study. The maximum age limit is sixty-five years.

Although applications will be rated as received at the Commission's Washington office, qualified persons are urged to file their applications at once. Further information and application forms may be obtained at any first- or second-class post-office, or from the U. S. Civil Service Commission.

AIRCRAFT TUBING PAPERS

The James F. Lincoln
Arc Welding Foundation
Cleveland, Ohio, U. S. A.

April 5, 1941

Mr. Wm. Spraragen, Tech. Sec'y & Editor,
The American Welding Society,
33 West 39th Street,
New York, N. Y.

Dear Mr. Spraragen:

I have noted with interest the announcement of the Summerill Tubing Company, Bridgeport, Pa., of the establishment of a series of prizes for papers to advance the art of welding of aircraft steels including tubing and other steel parts for tubular assemblies.

My purpose in writing you is to point out that papers submitted in the Summerill contest will also be eligible in the $200,000 Industrial Progress Award Program which is being sponsored by The James F. Lincoln Arc Welding Foundation, provided, of course, that such papers comply with the Foundation's Rules and Conditions as regards subject matter and form.

It is conceivable that a paper entered in the Summerill contest would be written in such a way as to be acceptable in the Lincoln Program. If it is not acceptable as written, the author, by a few changes or additions, could make it conform to the Foundation requirements.

I felt this would be of interest since eligibility in the two projects should provide added stimulus to the study of welding in the aircraft field.

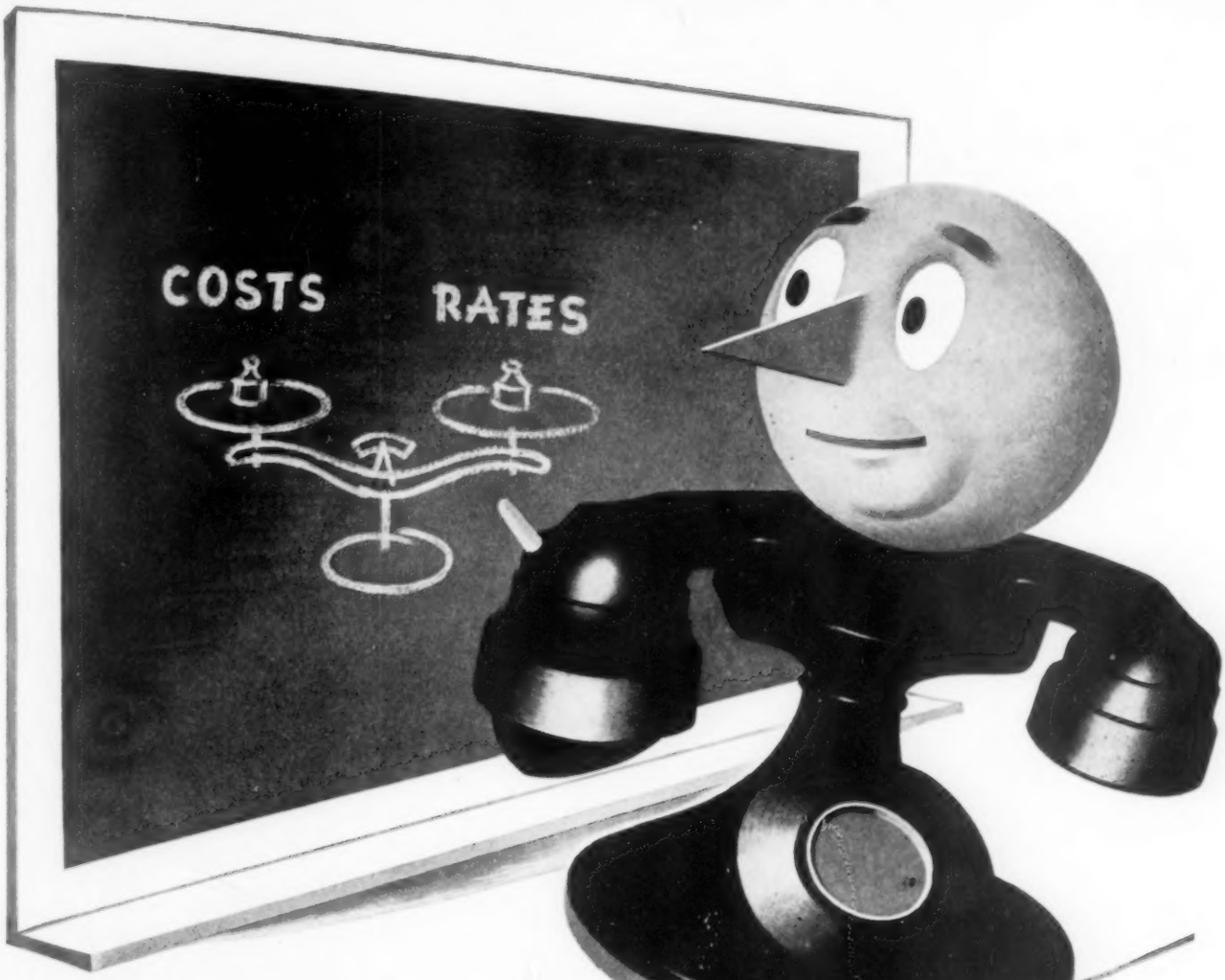
If you care to publish this letter you may do so.

Very truly yours,
The James F. Lincoln Arc
Welding Foundation
Ed C. Powers, *Assistant Secretary*

NEW EXAMINATION FOR ENGINEERS

On April 7th, the United States Civil Service Commission announced a new examination for engineering positions in the Federal Government. Engineers making application for jobs, except those applying in chemistry, metallurgy, marine or naval architecture which are covered by other announcements, should now apply under the modified terms of the new announcement. However, persons who have been rated eligible under the examinations announced in 1940 for mechanical, aeronautical, civil or general engineer need not file new applications. They will be placed on the list of persons eligible for appointment as the result of the new examination.

The positions pay from $2600 to $5600 a year. Applications will be rated as they are received at the Commission's Washington Office until June 30, 1942. Engineers qualified in the following specialized fields are particularly needed for the National Defense Program and are urged to file their applications at once: aeronautical, agricultural (farm machinery), construction (airports and buildings), heating and ventilating, mechanical (industrial production and Diesel design), ordnance, radio, safety, sanitary (especially public health), structural (building design) and welding.



Doing his best with a tough job

The hardest job of the Bell System is to give you more and better telephone service and yet keep rates low. It isn't easy to keep those two things in balance. Increasing costs and taxes make it difficult.

But there is no end to trying. There is never any letting up in the search for a better, more economical way. All along the line, the Bell System believes in economy in business housekeeping. That is part of its obligation to the public.

BELL TELEPHONE SYSTEM

Listen to "The Telephone Hour" every Monday. (N. B. C. Red Network, 8 P. M., Eastern Daylight Saving Time.)

The duties of these positions will include design, construction and research in the various branches of engineering. To qualify for the examination, applicants must have completed a 4-year college course in engineering and have had broad and progressive engineering experience. In general, this experience should have been of a kind which required thorough knowledge of mathematics, economics and the physical sciences. Under certain conditions additional engineering experience may be substituted for all or part of the education, and approved graduate study may be used for the experience requirement. The maximum age limit is 60 years.

Further information and application forms may be obtained at any first- or second-class post-office or from the Civil Service Commission, Washington, D. C.

SIX NEW SPECIFICATIONS COVERING IMPORTANT MATERIALS APPROVED AT A. S. T. M. STEEL COMMITTEE MEETING

As the result of a very constructive series of meetings held in Washington during A. S. T. M. Committee Week, March 3rd to 7th, Committee A-1 on Steel approved for reference to letter ballot of its some 229 members six proposed new specifications.

The new specifications for low-alloy structural steel developed in a section headed by C. F. Goodrich, Chief Engineer, American Bridge Co., cover material with a composition conducive to weldability, intended primarily for use as main stress-carrying material of structural members. These specifications are limited to material not under $^3/_{16}$ in. and not over 2 in. in thickness. The maximum permissible carbon in ladle analysis is 0.20 per cent (check analysis, 0.22) and the maximum manganese is 1.00 (check analysis, 1.05). It is stipulated that the manufacturers shall use alloying elements which, combined with the carbon, manganese and sulphur limits, will produce properties meeting the minimum specified. Because of the intensive interest in welding, the subcommittee has included a note indicating that if steel is purchased for this purpose, the suitability of the chemical composition to be furnished shall be based upon evidence acceptable to the purchaser. The tensile strengths required for this grade of steel range from 63,000 to 70,000 psi, depending upon the thickness range and the relatively high yield points which characterize various compositions coming in this class range from 40,000 for material over $1^1/_2$ in. to 2 in., inclusive, in thickness to 50,000 psi for thinner material. Many of these types of steels have come on the market in recent years.

Another important development in the work of Subcommittee II on Structural Steel for Bridges, Buildings and Rolling Stock which is headed by F. H. Frankland, Chief Engineer, American Institute of Steel Construction, is the work of the section on welding of structural steels, under the chairmanship of Jonathan Jones, Chief Engineer, Fabricated Steel Construction, Bethlehem Steel Co. His section reached agreement at the meeting on changes which might be set up in the Standard Specifications for Steel for Bridges and Buildings A 7 – 39 to cover the weldability of this material. One of the important problems has been to provide chemical limits, particularly for carbon and manganese, as well as physical properties which are now given. While no definite recommendations are being made now, the proposed revisions are to be referred to various parties for study and comment, in the anticipation that sometime within the coming year specific action of the Society may be requested. On invitation a number of important users of the material were present at the meeting to give the benefits of their experiences on welding and also people who are conducting studies of weldability.

PAGE APPOINTMENTS

J. E. Skinner was recently placed in charge of Welding Wire Sales, as assistant to W. H. Bleecker, Sales Manager, at the general sales office of Page Steel and Wire Division, American Chain & Cable Company, Inc., Monessen, Pa., taking over the duties previously performed by V. H. Godfrey who was recalled to active duty with the United States Navy.

W. G. Hoagland of the Chicago office of Page Steel and Wire Division was transferred to Monessen, Pa., to take over the duties previously handled by J. E. Skinner.

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Use National Carbide in the Red Drum

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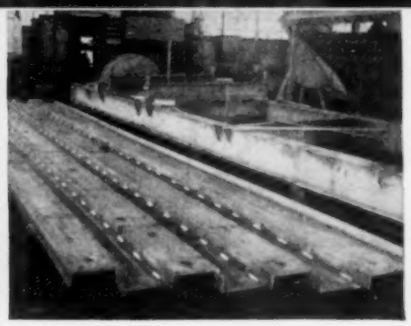
Have You Cut Your Welding Costs 10% Lately?

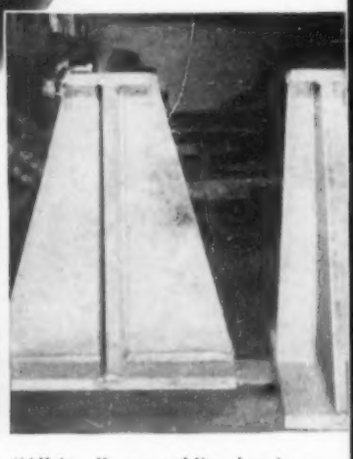
Where the going gets tough, where magnetic blow restricts the use of higher currents to get faster production—that's where a-c welding is called upon by modern shops.

Mr. Wm. E. Hendricks, Plant Mgr., Belmont Iron Works, Philadelphia, says, "the use of a-c welding has simplified the application of welded design to structural work, and—



"In many cases, inaccessible seams, such as bases of columns with shear plates and seams with bad fit are more easily welded with an a-c arc. Another thing—there's less arc blow and less tendency toward undercutting—

"As for our welding operators, it is safe to say that they're all better satisfied with their work because a-c gives their jobs a smooth appearance, free from blow-holes, undercut, and starting and stopping craters—



"All in all, a-c welding has been everything they said it was! Our type of work is heavy, we're a production shop—we must get it out—and a-c does just that. It helps us get it out, on time, and welded right!"

IF you're pressed for production—if you're bothered by magnetic blow slowing down your operators and adding to your costs—why not investigate a-c welding? Your nearest G-E arc welding distributor will be glad to demonstrate a-c on your work, at no obligation. You can depend on his recommendations because he handles the G-E line of welders, the most complete line on the market, including a-c, d-c, atomic-hydrogen—in fact, 'most any kind of an arc welder you're likely to need. (He doesn't have to "push" *any particular* type of welding.)

For reliable and unbiased information, therefore, on the type of welding for the kind of work you do, see your G-E arc welding distributor today—or write direct. General Electric Company, Schenectady, New York.

GENERAL ELECTRIC

672-27-8743

"After more than eight years of experience, under all sorts of circumstances, WE KNOW A-C WELDING HAS REDUCED OUR WELDING COSTS 10%!"
Wm. E. Hendricks,
Plant Manager,
Belmont Iron Works,
Philadelphia

E. A. DANIELS—GENERAL SALES MANAGER

Fourteen years ago E. A. Daniels—"Dan" to his associates and his hundreds of friends—began his selling career with Victor Equipment Company. He had previously had much experience in both

E. A. Daniels

gas and electric welding and had been welding foreman at the Avon refinery of the Associated Oil Company.

A likable personality coupled with an inherent desire to learn, soon made Dan one of the company's star salesmen and because he has satisfactorily executed every assignment and never permitted an imaginary time clock to impede his progress, Victor Equipment Company gladly announces his appointment as General Sales Manager.

NAVY OFFICIALS INSPECT DEFENSE PLANT

A new defense construction program embracing a total of well over 100 fighting ships and 30 cargo vessels and tankers was launched officially April 11th, as Ralph A. Bard, The Assistant Secretary of the Navy, inspected steam propulsion apparatus under construction at the Westinghouse Steam Division plant, Lester, Pa. The plant is working 24 hours a day turning out more marine propulsion equipment than any other American factory. Total capacity of steam turbines to be produced in the current program for naval vessels exceeds 7 million horsepower.

The Steam Division, with a backlog of orders exceeding $130,000,000, is also building land turbines which have a total capacity of 2,400,000 horsepower for power plant and industrial use. The company is spending $9,000,000 in this plant alone for new manufacturing shops, machine tools and reorganization of facilities for defense production. Output of vital Navy equipment will be more than double that of normal times. The plant expansion program, started last fall, should be completed in 1941.

Manufacturing operations are among the most accurate found in heavy industry. The largest power plant turbine, now being built, will produce as much as 250,000 horsepower; the smallest turbine produces $1^1/_2$ horsepower. Both are built with hair-breadth accuracy, requiring precision finished parts with tolerances of a few thousandths of an inch. Bull gear wheels weighing 15 tons are machined in air-conditioned tool rooms so that temperature changes will not affect finish. Gear tooth surfaces are held to a tolerance of less than 0.0002 inch.

More than 400 new machine tools, ranging in size from 200-ton gear planing machines to finishing machines which weigh but a few hundred pounds are being installed in the shop, and approximately 5000 persons, working three shifts, keep the plant in production 24 hours a day. About 300 apprentices are being trained to operate the new machines.

Fig. 1—Part of $9,000,000 Defense Plant Expansion. Welding Steel Supports for a Mobile Overhead Crane in One of the Westinghouse Steam Division's New Manufacturing Shops

The plant has more than 35 acres of manufacturing floor space and a railway system comprising nearly 11 miles of standard gage track.

LINCOLN ELECTRIC WELDING CONSULTANT

The Lincoln Electric Company, Cleveland, Ohio, announces the appointment of Mr. B. J. Brugge as its Welding Consultant and Engineer at Washington, D. C. He will be engaged in consulting work having to do with the application of arc welding in the National Defense Program and will be available for such work with all governmental departments. He will be associated with T. A. Canty, Inc., Lincoln representatives in Baltimore, Maryland.

He is a graduate of Purdue University and began his career in arc welding with two years in the Lincoln research laboratory. In 1935 he was granted a leave of absence to assist in the application of electric welding in the Near East. Serving in the capacity of welding superintendent for the Anglo-Iranian Oil Company, he spent two years at Iran, Persia, supervising welding operations in construction

B. J. Brugge

of refineries and pipe lines. He directed the training of many Persians in the art of welding and increased the Anglo-Iranian Company's welding forces from 30 to 120 arc welders.

Following his work in Persian oil fields, Brugge spent four months in the British Isles as welding consulting engineer for British and Scottish firms.

Mr. Brugge, who has been associated with Lincoln since 1931, was formerly in the Los Angeles office and until recently located in Houston, Texas.

E. H. EWERTZ

During Mr. Ewertz' stay at the Manitowoc Shipbuilding Co., Manitowoc, Wis., he will maintain and operate his Consultant Engineers Office in New York, 29 Broadway. Affairs will be handled by his son and Mr. Wm. Reed-Hill.

WELDED STEEL BASE PLATES

A new 8-page Booklet No. 1882, covering the company's line of welded steel base plates for adjusting pillow blocks and common flat boxes for shaft alignment, is announced by Link-Belt Company, 2410 West 18th St., Chicago.

Types *A* and *B* base plates are tabulated, for mounting pillow blocks of shaft sizes up to 8 inches. List prices, dimensions and weights are given.

Type *A* Base Plates, for horizontal adjustment only, consist of a welded steel frame fitted with either one or two adjusting screws. The extent of horizontal adjustment is limited only by the length of slotted bolt holes in the bearing itself.

Type *B* Base Plates, for both horizontal and vertical adjustment, consist of a welded steel frame, two cast-iron wedges, and two sets of adjusting screws. One set of screws, by changing the relative position of the sliding wedges, provides for vertical adjustment of pillow block; the other set regulates horizontal adjustment. The bearing bolts pass through slotted holes in the wedges, and both horizontal and vertical adjustments are limited only by the length of the slotted bolt holes in the bearing itself.

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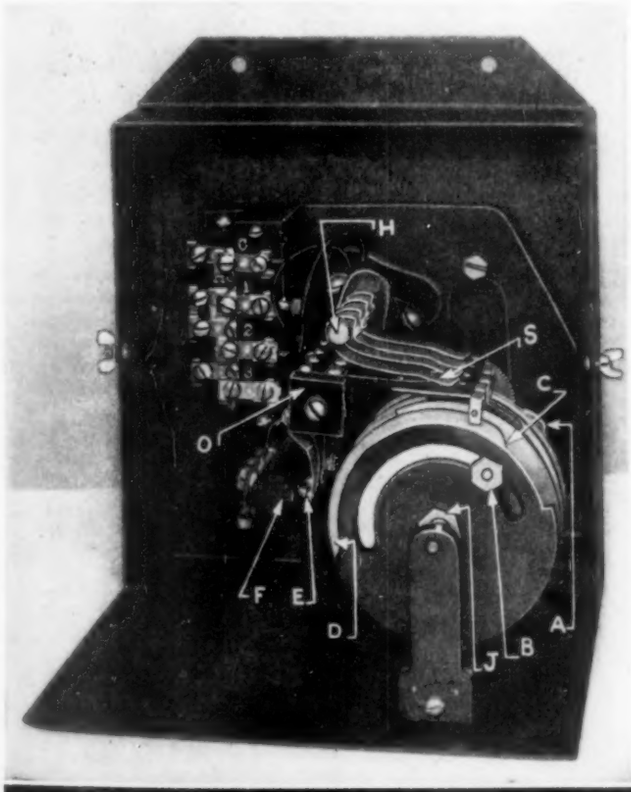

Oh, Yes! FOR HIGH SPEED SEAM WELDING

National Type 1770 Vari-Speed Timer Does a Fine Job

Moderately priced — Consistent — Makes from 400 to 900 Spots per Minute in 17 Stages by a Simple Gear Change

This Motor-driven, Cam Operated Timer interrupts the Welding Current, passing through the rolls of the Seam Welding Machine. Every Revolution of the Timer Cam Assembly, four spots are welded.

The proximity of the spots is regulated by the feed of the metal between the rolls, and the rotating speed of the Timer. Speed up the Timer, without increasing the feed, and welds occur closer together.

Weld "ON" time is easily adjusted by loosening the nut "B," and moving the shutter in back to desired position. All Operating Functions are in Plain View, with Nothing left to the Imagination.

It is this plain Simplicity, and Open Book Structure, an Exclusive National Timer Feature, that appeals to the Men Behind the Guns, who have to live with them, Day In, and Day Out. No Wonder Operators Prefer National.

Fully described in Bulletin No. 146, just published

NATIONAL TIME & SIGNAL CORPORATION

600 E. MILWAUKEE AVENUE DETROIT, MICHIGAN

WELDING ROD PRODUCTION CAPACITY TERMED ADEQUATE

Manufacturers of electric arc welding rods, discussing production capacity at a meeting held recently, pointed out that, with the installation of a relatively small amount of new equipment, there will exist in the industry the ability to produce approximately 400,000,000 lb. of welding rods annually. This is roughly twice the quantity of electric arc welding rods used during the year 1940.

Despite the tremendous growth in the use of arc welding in the past few years and the fact that the consumption of arc welding rods increased 40% in 1940 and, due to the increase in the relation between sales of welding rods and ingot production, may increase another 50% in 1941, it is felt that the ability to double its production puts the welding rod industry in an excellent position to cope with the situation. In this connection, it was brought out that steel mills have been operating virtually at capacity for some months and that, therefore, there should be no appreciable future increase in rate of ingot production to be considered as a factor in the demand for welding rods. Further, it is thought that the recent sudden influx of welding rod orders, which is partly due to fear of future scarcity and the desire on the part of users to build up stocks against such a contingency, will soon taper off. Any further rise in consumption of arc welding rods is expected, therefore, to be simply a normal rise resulting from a growing use of the arc welding process.

The large increase in the number of electric welding machines sold during 1940 has not, it is thought, affected the situation appreciably as new machines sold last year comprise only a small proportion of the total number of machines now in use.

All in all, even in the face of the Defense Program, there appears to be every assurance that there will be no lack of supply of electric arc welding rods.

HANDBOOK OF WELDED STEEL TUBING

Improvements and refinements which have been made in the processes employed for manufacturing welded carbon and alloy steel tubing during the past ten years have resulted in the adoption of this material for structural uses in many large industries. There are inherent advantages in welded tubing due to the fact that it is formed from flat rolled strip and therefore has high physical properties and true concentricity of section. The *Handbook of Welded Steel Tubing*, published by the Formed Steel Tube Institute, has been published to furnish designing engineers with full information regarding standard sizes and properties of welded tubing. The book is exclusively devoted to those grades of welded tubing which can be figured as having a solid wall structure with no discontinuity or variation in physical properties occurring in the area affected by the welding operation during manufacture. Standard sizes, together with commercial tolerances for roundness, wall thickness, straightness, etc., are tabulated for various grades of welded tubes. The manufacturing and fabricating processes are illustrated, and dimensioned drawings show on typical examples to what degree welded tubing can be cold worked in such operations as bending, beading, flanging, expanding, tapering, etc. Special attention is given to recommendations for laying out fabricated parts and methods of checking. The reader is further provided with suggestions which will aid in developing designs for the most economical use of tubular sections. Numerous illustrations have been selected to show the wide variety of possibilities for using tubular members in addition to its present large-scale use in the automotive and furniture industries. The Handbook is of pocket size in a durable loose-leaf binding. Copies can be obtained from Formed Steel Tube Institute, 1621 Euclid Avenue, Cleveland, Ohio. Eighty-six pages. Price, $1.00.

FREDERICK H. DILL APPOINTED

Members of the AMERICAN WELDING SOCIETY will be interested in the appointment of Frederick H. Dill as welding engineer, American Bridge Company, with headquarters at Ambridge, Pa.

For SAFETY SPEED ECONOMY

MANIFOLDS
REGULATORS
VALVES and
FITTINGS
to control high pressure gases

The BASTIAN-BLESSING Co.
282 E. ONTARIO ST. CHICAGO

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The Sales Manager Says...
"Field returns have practically disappeared since we adopted Mallory Standardized Welding Tips."

Better fabrication soon wins the applause of the "men on the firing line." Nothing contributes more to successful selling. And in the field of joining similar or dissimilar metals nothing has contributed more to speed and efficiency than Mallory's extensive program of standardization of welding electrodes.

Standardization has produced better, lower cost welding electrodes because field experience has proven the exact requirements for proper cooling, hardness, thermal and electrical conductivity. Mallory Electrodes assure more welds between redressing . . . and a far greater number of welds before replacement is necessary. In addition, standardization has eliminated costly delays while waiting for special orders to be completed. Why not share in the advantages of Mallory's great investment in the interests of better resistance welding?

MALLORY
Resistance Welding Data Book

Typical of Mallory's thoroughness is this technical reference to all phases of resistance welding. Written by recognized experts, it deserves a permanent place in your engineering library. Write for your copy today.

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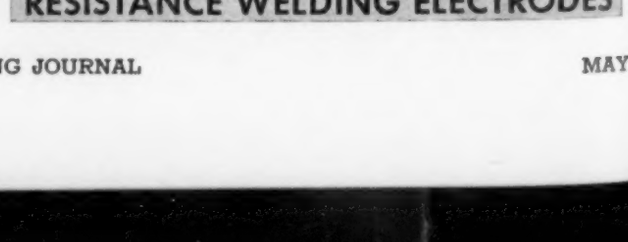
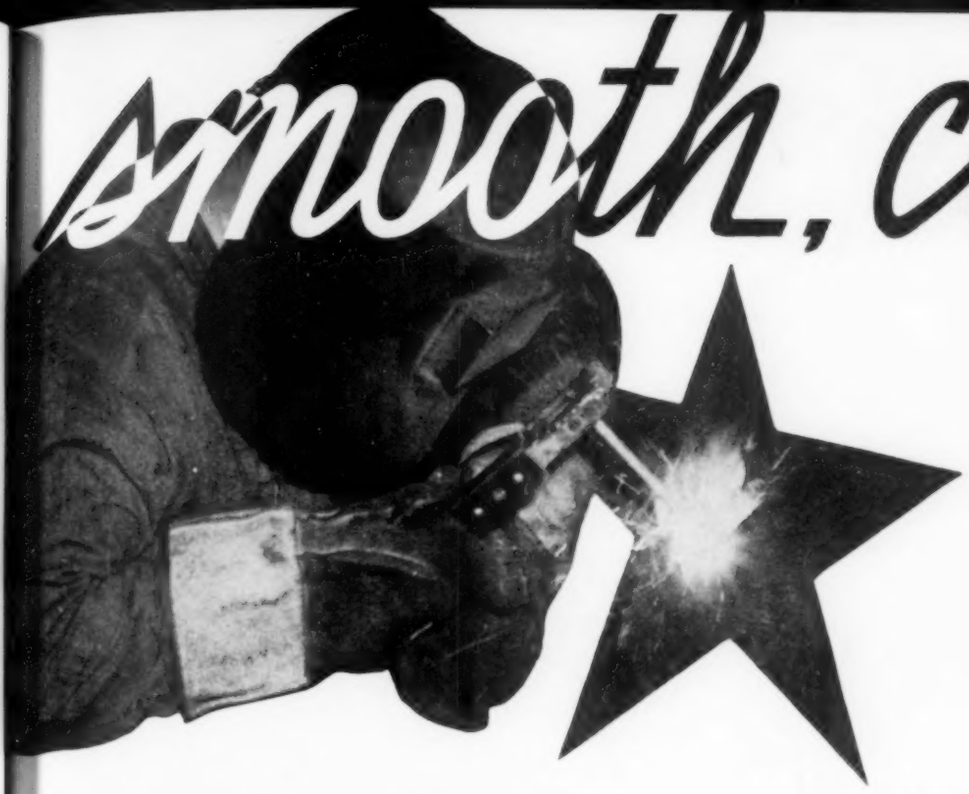


smooth, clean



murex welds

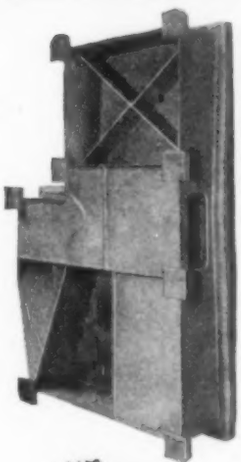
. . . cut grinding and finishing costs

Surveys among users of Murex electrodes show that one of the reasons for Murex preference is their ability to produce smooth, good looking welds on machine tool frames, domestic appliances, and other equipment where appearance is an important factor.

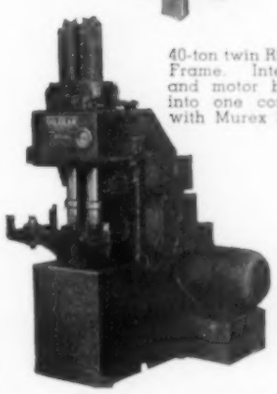
The sketch below illustrates a recent application of Murex electrodes for corner welds on bases for hydraulic presses. The report from the field reads, "The welders have become so expert in producing a smooth, well crowned bead with Genex that very little grinding is required for a smoothly finished, perfectly rounded corner."

In this instance both Fillex and Genex were used—Fillex for filling up the "V" and Genex for the surface because of its quick setting characteristics in building up a convex surface.

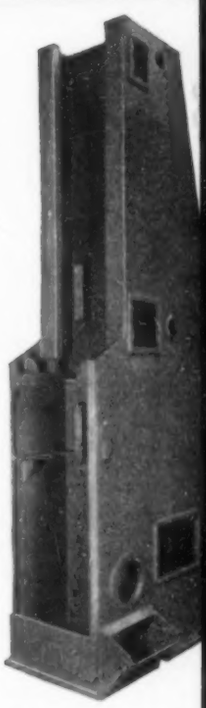
There are many ways in which Metal & Thermit engineers can help you improve welding technique, increase production and cut welding costs. Demonstrations gladly arranged.



Murex welded machine base, Mosler Safe Co., Hamilton, Ohio.



40-ton twin Riveting Press Frame. Integral pump and motor base welded into one compact piece with Murex Electrodes.



Frame for Vertic Broaching Machine we ed with Murex. R. Mahon Co., Detroit.

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MUREX HEAVY COATED ELECTRODES

THERMIT WELDING — STANDARD FOR 40 YEARS FOR WELDING RAILS AND HEAVY EQUIPMENT

Fig. 2—The S.S. *E. H. Blum* Is Taken in Tow by Tugs After Being Launched at the Chester, Pa., Yards of the Sun Shipbuilding and Dry Dock Co.

Fig. 1—The Launching

NEWEST ATLANTIC TANKER LAUNCHED

The S.S. *E. H. Blum*, newest tanker of The Atlantic Refining Company fleet, is launched at the Chester, Pa., yards of the Sun Shipbuilding and Dry Dock Co. The vessel was completed in record time. Her keel was laid Oct. 3rd and she will go in service April 1st, two days less than six months later. The new tanker is 544 feet overall, has a cargo capacity of 154,000 barrels of crude oil, and will operate between Texas gulf ports and Philadelphia. She is powered with 5000 horsepower turbo-electric engines and will have a sea speed of 13.25 knots.

INTERNATIONAL ACETYLENE ASSOCIATION COOPERATES IN FIRE PREVENTION PROGRAM

The National Board of Fire Underwriters, which this year is celebrating its 75th anniversary, has designated the week of May 21st to 28th as Anniversary Week, during which time it will focus the country's attention on the part played by fire prevention in national defense. The International Acetylene Association is cooperating in this program by making available to all those engaged in welding and cutting work copies of its booklet, "Preventing Welding and Cutting Fires."

"Fire prevention and fire protection cannot be overemphasized in times of increased industrial activity," a spokesman for the International Acetylene Association said in announcing the Association's participation. "With industry gearing itself for greater and greater production, every effort must be made to conserve our assets and prevent waste. It is particularly appropriate, therefore, that the 75th anniversary celebration should, at this time of national emergency, again call attention to the importance of fire prevention."

It was pointed out that the oxyacetylene industry has long stressed the need for safety and fire prevention, and that the splendid safety record which has been established down through the years is a tribute to all those who have had occasion to do welding or cutting work. It was urged that all welding operators, however, exercise special vigilance during the present emergency. Copies of the 16-page booklet, "Preventing Welding and Cutting Fires," can be obtained by writing to The Secretary, International Acetylene Association, 30 East 42nd Street, New York, N. Y.

THEY PRACTICE WHAT THEY PREACH

With two miles of weld embodied within its sunshiny structure, Hobart Trade School now being completed in Troy, Ohio, exposed its modernistic face last week. Built entirely of arc-welded steel, this two-story structure has a frontage of

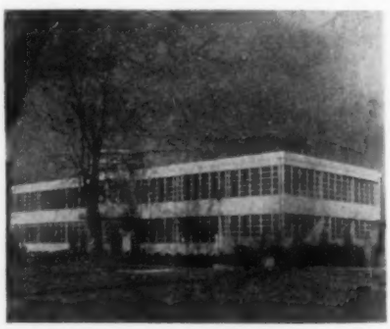

Photo courtesy Hobart Brothers Co., Troy, Ohio

125 feet and a depth of 60 feet. The school's training courses will completely qualify young men for electric arc welding and general machinist trades. O. H. Menke, president of the school, announced recently that the school is receiving the final touches and will be ready for use April 1st.

Buy "Proven Fluxes" with Years of Guaranteed Satisfaction behind them
The Trade-Name is "ANTI-BORAX"

Ask for Them *Unequalled for Quality*

A Flux for every metal: Cast Iron Welding Flux No. 1; Brazing Flux No. 2; Braz-Cast Flux No. 4, for bronze-welding cast iron; "ABC" Aluminum Flux No. 8 for sheet Aluminum and all alloys of Aluminum; Stainless Steel Flux No. 9; Silver Solder Brazing Flux No. 10; "Anti-Borax" Tinning Compound No. 11.

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Fort Wayne, Indiana

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For
OXY-ACETYLENE WELDING AND CUTTING OF METALS

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EMPIRE STATE BUILDING
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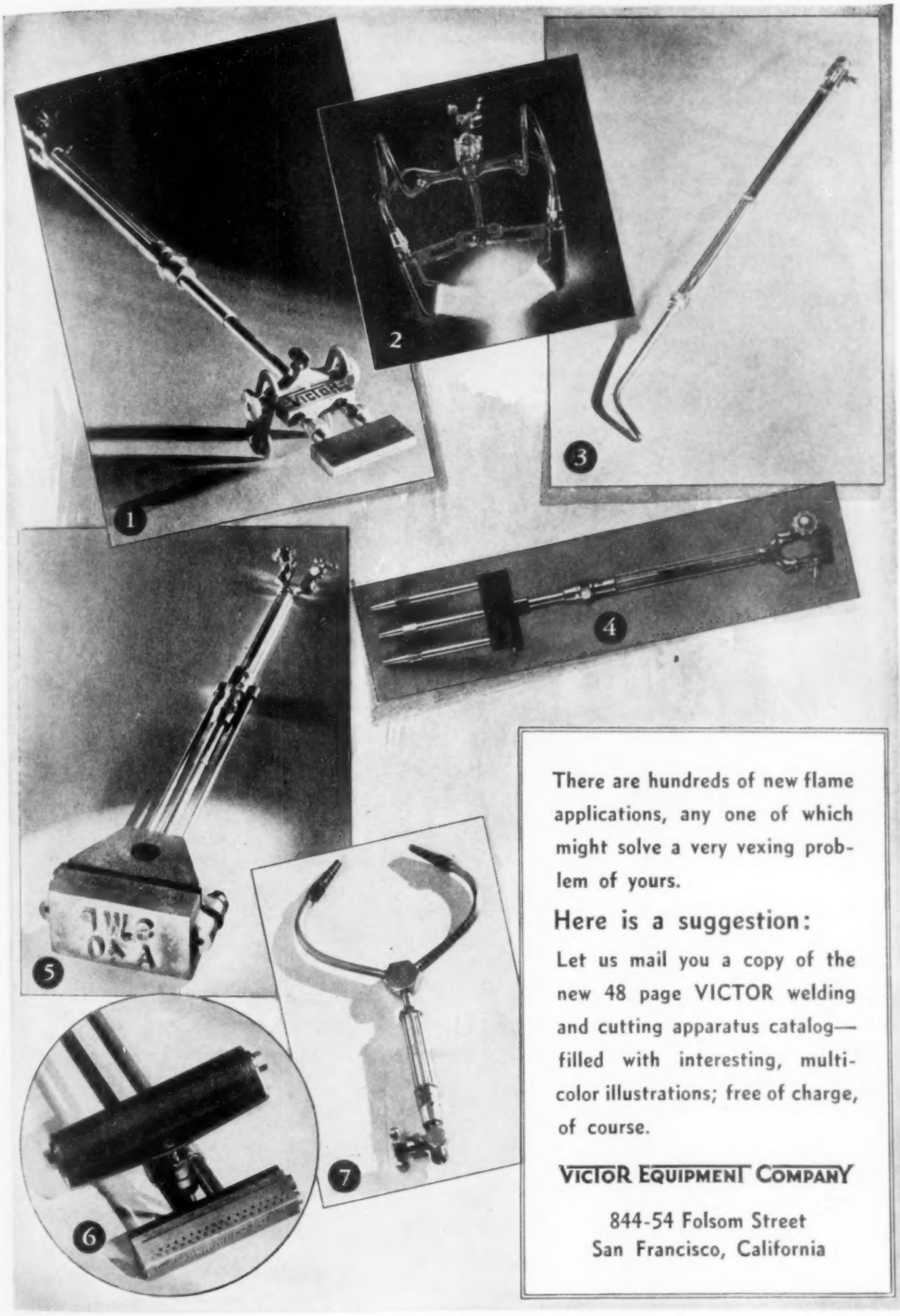

There are hundreds of new flame applications, any one of which might solve a very vexing problem of yours.

Here is a suggestion:

Let us mail you a copy of the new 48 page VICTOR welding and cutting apparatus catalog—filled with interesting, multi-color illustrations; free of charge, of course.

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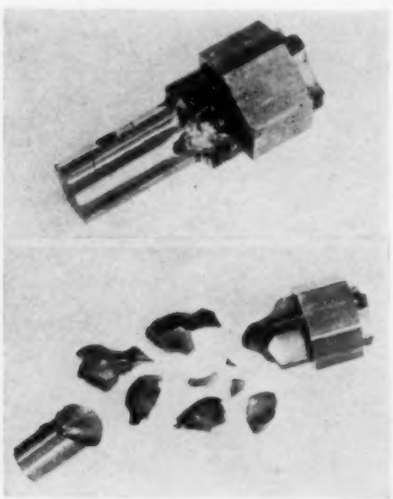
San Francisco, California

A FAST REPAIR OF A SPECIAL TAP

In a large mid-west plant a special $1^3/_8$-in. tap was shattered in service. It broke in ten pieces of various sizes and shapes and threatened to tie up production on an important job. A check-up with tool manufacturers brought the advice that a new one could not be delivered for six weeks so the tool maintenance department decided to attempt a repair. The head of this department, familiar with high-speed steels, knew that welding was impossible but had a hunch that low-temperature silver brazing alloys might do the trick.

When the Tap Was Finished Fine White Lines in the Shank Indicated Where Parts Were Joined



Photos courtesy Handy & Harman

The Ten Irregular Pieces That Had to Be Brazed

He had all parts cleaned carefully and fluxed with a low temperature flux. Parts were then assembled and held closely together in a milling machine vice. Heating was done with an oxyacetylene torch and the alloy used was Easy-Flo, a medium silver alloy flowing freely at 1175° F. The exceptional penetrating qualities of this alloy, it was felt, would let it flow throughout the many surfaces that had to be joined. How well this repair was completed can be judged by the fact that the tap was back in service in four hours. That was last October. A report dated January 11, 1941, states that the tap is still in use. The actual brazing time for this job was but $^1/_2$ hour and but 3 in. of $^1/_{16}$ in. diameter wire were used to make the repair. The only fault detected after brazing was that the tap is 0.005 in. out of center, which made no great difference on the particular work being done. The job proved conclusively, however, that a braze of this type gives plenty of strength to withstand severe service conditions.

WIRE 1/2000 OF AN INCH SPOT WELDED

At General Electric's General Engineering laboratory in Schenectady, nickel-chromium wires but $^1/_{2000}$ of an inch in diameter ($^1/_4$ the thickness of a human hair) are being spot welded together into tiny filaments for sensitive thermocouples —small tube-like devices (about size of small flashlight bulb) used to measure high-frequency, alternating currents or voltage.

Each filament consists of three pieces of wire, spot welded into a K shape. The filament itself is then spot welded to the posts of the thermocouple stem. So detailed is the work that the operator must use a microscope to see the wire and a pair of small tweezers to hold the wire. Dexterity, keen eyes and patience are the prerequisites for this exacting job.

PHOTOS FROM SOUTH AMERICA SHOW INTERESTING USES OF WELDING

Shown in the accompanying illustrations, supplied by The Lincoln Electric Company, Cleveland, Ohio, are some interesting uses of arc welding photographed in Brazil.

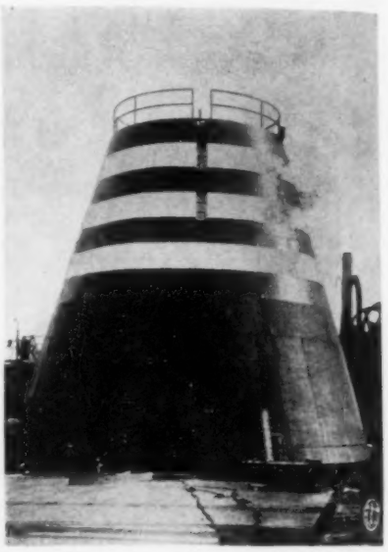
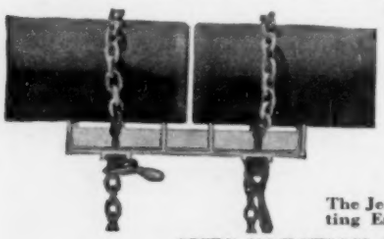


Fig. 1

Sea Observation Tower: Height 9.50 meters. To sit on a concrete block 9 meters high. Top diameter 5.80 meters. Bottom diameter 12.00 meters. Thickness of plates 3, 4.5 and 6 millimeters. Total weight of metallic structure 34 tons (Fig. 1).

Dragline Dredge: With centrifugal pump for the pumping of the material through pipe line over a distance of 250 meters. Overall length 32.00 meters. Main breadth 8 meters. Depth 2.00 meters. Draft 1.00 meters. Displacement 188 tons. Built of 6-millimeter

PIPE WELDING TOOLS THAT MAKE WELDING PAY



Pipe Clamps
Flange Clamps
Elbow Clamps
Angle Clamps
Pipe Markers

TWO SIZES
½ to 8 in. 8 to 16 in.
Light—Adjustable—Fast

The Jewel System of Pipe and Fitting Erection Ready for the Weld

CUTS ERECTION COSTS

Keeps the Welder Welding Instead of Waiting

JEWEL MANUFACTURING COMPANY
1841 University Ave., St. Paul, Minn.

SAVE MONEY . . . BY WELDING

Jaw Plates, Gyratory and Roll Crushers, Shovel Teeth, Hammers, Tractor Tread Grousers

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MANGANAL

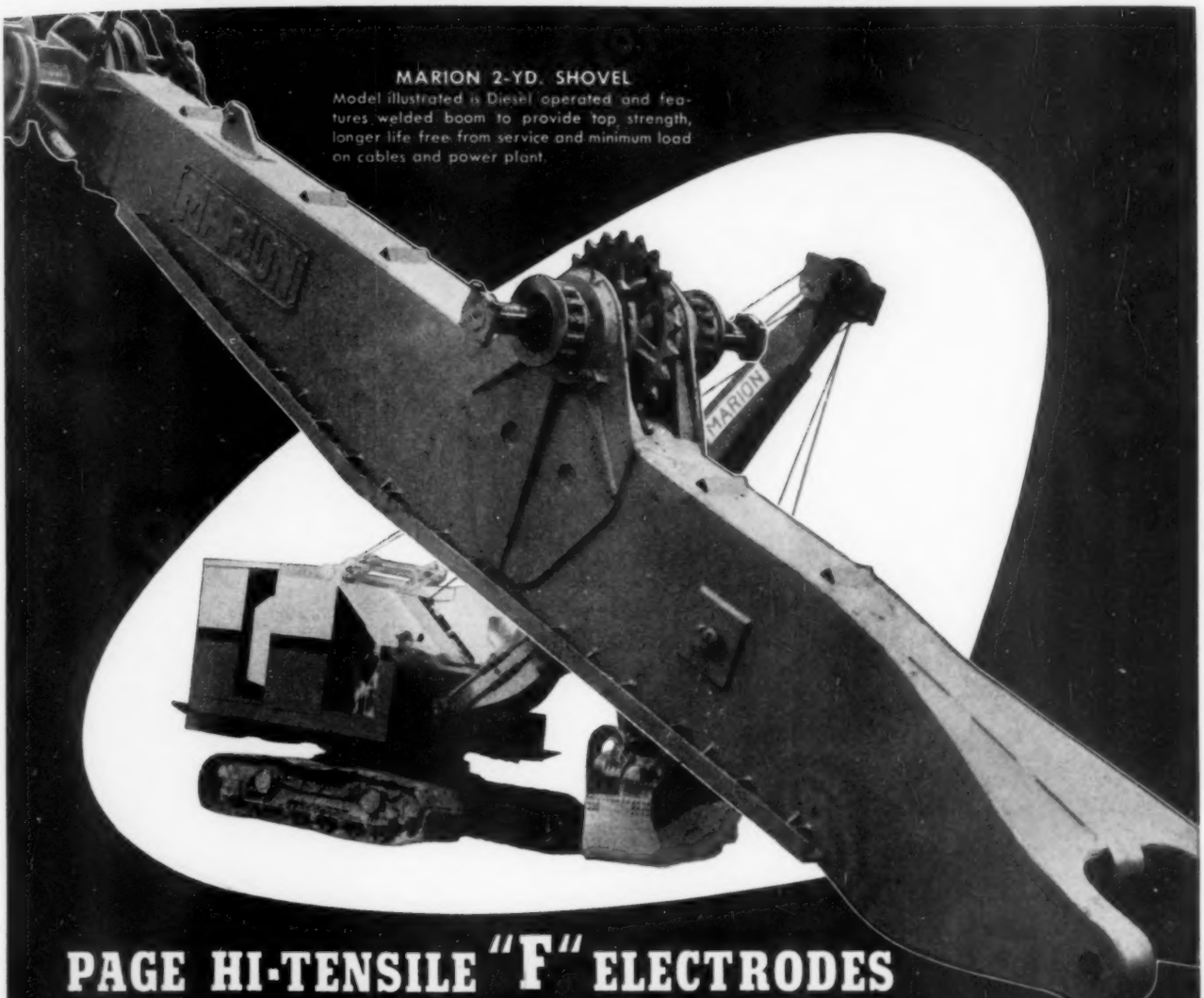
Reg. U. S. Pat. Office. U. S. Patents 1,876,738—1,947,167—2,021,945

11 to 13% Manganese Nickel Steel

WELDING ELECTRODES, WEDGE and APPLICATOR BARS, HOT ROLLED PLATES

STULZ-SICKELS CO *Sole Producers* 134-142 Lafayette St., Newark, N. J.

Sold Thru Distributors Only



MARION 2-YD. SHOVEL
Model illustrated is Diesel operated and features welded boom to provide top strength, longer life free from service and minimum load on cables and power plant.

PAGE HI-TENSILE "F" ELECTRODES

again help make a better product

—LIGHTER and STRONGER

The 23-foot boom of this Marion Shovel is welded because Marion Engineers find the welded boom to be stronger, longer lasting and lighter in weight—qualities that are mighty important to the shovel operator.

But don't overlook the value of PAGE HI-TENSILE "F" Electrodes in this operation—permitting excellent speed with a minimum of spatter and slag loss and providing the smooth beads that good welders want to mark their work.

You, too, will find it worthwhile to ask your local PAGE Distributor to give you the facts about PAGE HI-TENSILE "F"—shield-arc type electrodes for horizontal, vertical or overhead welding.

Get this Free Booklet

Ask your local PAGE Distributor for a copy of this well illustrated booklet. It contains valuable information on 3-position shield-arc welding of carbon steels.

PAGE WELDING ELECTRODES

PAGE STEEL AND WIRE DIVISION • MONESSEN, PENNSYLVANIA

AMERICAN CHAIN & CABLE COMPANY, Inc.

Fig. 2

plates. Bulkhead 4.7 millimeters. Deck 4.7 millimeters. "T" stiffeners 64 x 64 x 8 millimeters and 75 x 64 x 8 millimeters. Power of machinery: dredge 86 horsepower. Steam-driven centrifugal pump 70 horsepower. Capacity 100 cubic meters of solid material per hour (Fig. 2).

Fig. 3

Pipe: This unusual looking structure was fabricated for use in irrigating a rice plantation (Fig. 3).

MAINTENANCE

Flame Hardening.—Oxyacetylene flame hardening provides a convenient and economical means of imparting a wear-resistant surface to iron and steel parts without affecting the ductility and shock resistance of the core. An outstanding advantage of this operation is that the process is a selective one, since the hardening can be restricted to those surfaces where it is needed. (Fig. 1.)

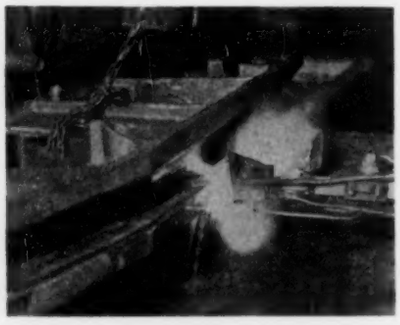
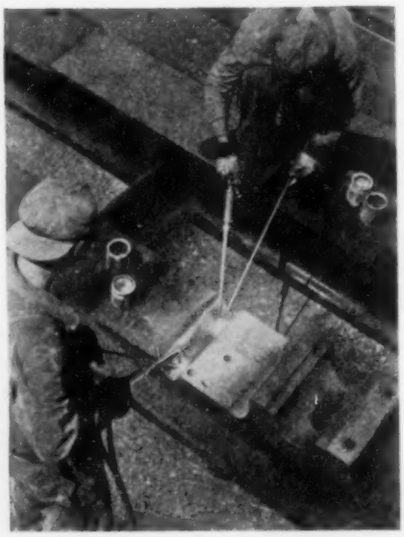


Fig. 1



Photos courtesy The Linde Air Products Co.

Fig. 2

Bronze Welding in Maintenance and Repair.—Plant maintenance men have in bronze welding a speedy and economical method of repairing breaks in a large number of metals whose melting points are higher than that of the bronze weld metal. Such metals include cast iron, steel, nickel and Monel metal. This 6-ton cast-iron bed frame for an upsetting machine was bronze welded at a fraction of its replacement cost, and returned to service with a minimum of delay. (Fig. 2.)

199 PIECES AT ONE TIME

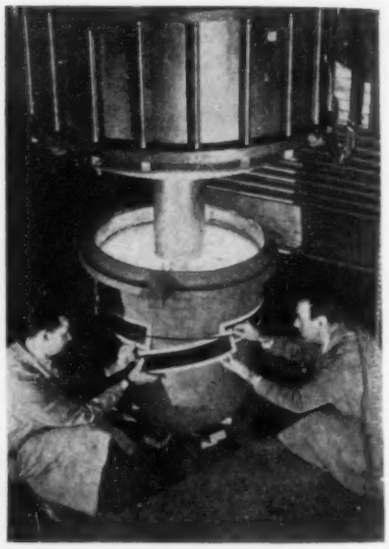
Pulsation welding, one of the many recent advancements in resistance welding,

enabled the temperature to be equalized across an entire assembly of 199 plates of $^1/_{32}$-inch low carbon steel, making a satisfactory weld at the General Electric Works Laboratory, Schenectady, N. Y.

According to Mr. Redmond, no practical need is seen at this time for such large-scale welding of pieces, but this is one answer for those who have asked, "How many pieces of metal can I weld together at one time?" And 199 pieces is not the limit!

LOOKING INTO WELDS

Unlimited information as to the soundness of weld metal is being obtained at the General Electric X-ray laboratory in Schenectady where this 1,000,000-volt G-E X-ray unit (highest voltage X-ray unit now in industrial use) and smaller 200,000 and 400,000-volt equipments are handling an ever-increasing volume of industrial work. In addition to weld examination, huge castings are radiographed with this high-voltage equipment which is capable of taking a picture through four inches of steel in less than two minutes' time.



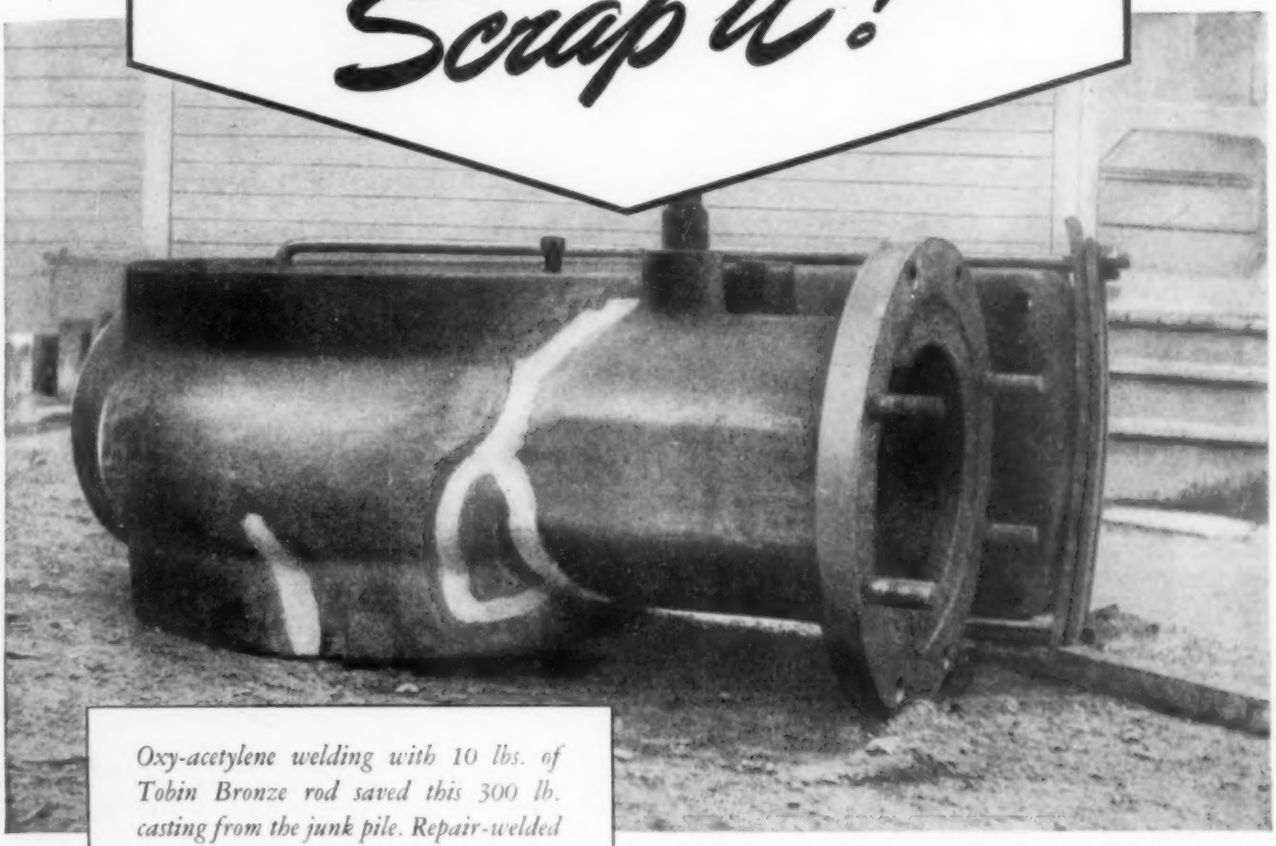
In this view engineers are placing an X-ray film holder over the welded joint of a fabricated lead pot casting preliminary to "looking into" the weld.

ALUMINUM BRONZE

"Controlled Aluminum Bronze for Aircraft Parts" is the title of a 12-page booklet just issued by Ampco Metal, Inc., Milwaukee, Wis., producers of Ampco Metal and other aluminum bronzes. The booklet is a reprint of an article by Mr. George K. Dreher, Ampco plant manager, which appeared in a recent issue of *Metal Progress*. The use of Ampco aluminum bronzes as essential alloys for the aircraft industry is discussed in detail. The booklet is well illustrated by photomicrographs, views of aircraft parts, charts and tables. Copies will be sent to those interested in the subject.

IN 1936—SOMEBODY SAID

"Scrap it!"



Oxy-acetylene welding with 10 lbs. of Tobin Bronze rod saved this 300 lb. casting from the junk pile. Repair-welded by Gemme Garage, St. Damase, Quebec.

But it was repair-welded with Tobin Bronze. Still going strong in December 1940!

When cracks appeared in the base of this crude-oil engine block, attempts to prevent their extension by clamps proved futile. In a short time they had practically encircled the cylinder —only fifteen inches of solid metal remaining between the ends of the cracks.

Replacement meant heavy cost and important time lost waiting for the new casting. It was then that Tobin Bronze welding was suggested. And just ten hours later, the engine base was ready to go back into service.

Every day similar cases demonstrate that expensive equipment, seemingly damaged beyond repair, can often be salvaged at nominal cost by welding with Tobin Bronze—a time-tried Anaconda product. The trademark "Tobin Bronze Reg. U. S. Pat. Off." is stamped in every rod. Look for it and be sure you get the genuine.

41138-A

ANACONDA
from mine to consumer

Anaconda Welding Rods

THE AMERICAN BRASS COMPANY, General Offices: Waterbury, Connecticut

In Canada: Anaconda American Brass Ltd., New Toronto, Ont. • Subsidiary of Anaconda Copper Mining Company

NEW PRODUCTS

The Society assumes no responsibility for the validity of claims in this Section

MULTIPLE SPOT WELDER

The Eisler Engineering Co. of 740–770 So. 13th St., Newark, N. J., has recently placed the illustrated Multiple Spot Welder on the market. The insets, lettered from A to H, show a few of the various multiple spot welding setups possible on this machine. Adjustments can be made to make circular, straight, square, rectangular or any odd shape welds, to conform with any need. From 2 to 12 spots can be made simultaneously, depending on the nature of the job.

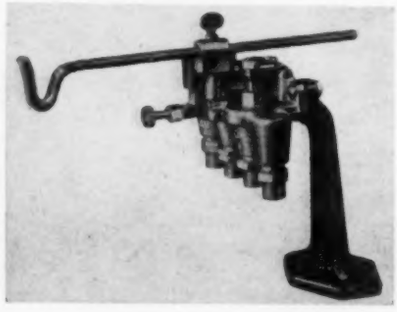
These machines are primarily intended for the spot welding of light sheet metal work where a large range of adjustments for various spots and shapes is to be considered.

Pressure electrodes are used with suitable air operation equipment. The electrodes have an individual adjustment so as to maintain an even pressure on all the spot welds being made.

REGO GAS ECONOMIZER

Where welding operations are intermittent. . . where welding torches are on and off due to work set-ups, the installation of a new Rego Economizer will save up to 30% in gas and operator time. The shut-off action is fast, positive and leakproof, due to the exclusive diaphragm-type shut-off valves. The body and diaphragm bonnets are heavy forged bronze.

Model 4360 is designed for very lightweight torches and for torches which operate at unbalanced gas pressures. The shut-off valves on the lever arm assembly are equipped with adjusting screws which, when set for the torch pressures being used, assures correct seating; an extendable lever arm provides



the adjustability required to assure positive shut-off with torches weighing but a few ounces. This model operates at unbalanced pressures as extreme as 3 ounces acetylene pressure with 50 pounds oxygen pressure; gives good performance with torches which operate at equal or balanced pressure up to 25 pounds; and by adding a weight to the lever arm will handle balanced pressures up to 50 pounds. A circular fully describing Rego Economizers is available from National Cylinder Gas Company, 207 West Wacker Drive, Chicago, Illinois.

SPOT-WELDING RECTIFIER

Designed especially for supplying required d-c current to magnetic energy-storage type spot welders such as are used for joining aluminum in the aircraft industry, a new ignitron spot-welding rectifier is announced by the Westinghouse Electric and Manufacturing Company. The new rectifiers are available in two capacities, one for use with 40-kw., the other for 120-kw. spot welders. Each rectifier will operate two welders if they are sequenced so that only one can be loaded onto the rectifier at a time.

The rectifier consists of a control and protective panel, power transformer and ignitron power tubes all contained in a forced ventilated floor mounted sheet metal cabinet with a heavy welded base frame. Tubes are arranged for water cooling, and cooling is controlled by a thermostatic water-flow switch. The control and protective panel is located in the top of the cabinet and the ignitron assembly in the bottom. Hinged doors provide access to the front of the cabinet and the back is removable for maintenance. A 14-in. fan, driven by a $^1/_3$-hp. motor cools the transformer, exhausting through a grill at the rear of the cabinet.

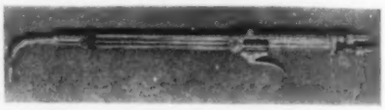
Further information on these ignitron rectifiers for magnetic energy-storage welders may be obtained by writing department 7-N-20, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania.

RISER CUTTING APPARATUS

In response to an increasing demand for greater convenience in removing riser heads from metal castings, Air Reduction has just introduced a new line of hand cutting apparatus. This apparatus consists of two torches and three tips.

The new torches, Styles 3180 and 9080, are of the straight head type. Both have monel metal heads and stainless steel tubes for longer life; each is 21 inches in length. Cutting oxygen can be controlled by either a lever or trigger, and the type selected can be placed on top, on either side or on the bottom of the torch to suit the convenience and comfort of the individual operator.

The new cutting tips are known as Style 187 bent to 75°; Style 181 bent to 90°; and Style 191 which is a straight tip, 7 inches long. They are designed to permit greater maneuverability in the restricted areas and cramped quarters frequently encountered in riser cutting. The shorter length from the end of the tip to the bend makes this possible.



While designed especially for cutting risers, this new Airco apparatus is also used successfully for removing rivets, for construction and repair jobs in shipyards, and as standard hand torches for regular and other special applications.

Further information about this new equipment may be obtained by writing to Air Reduction, 60 East 42nd Street, New York, N. Y.

ELECTRODES PERMIT MACHINING AND FLAME HARDENING

A new type of welding electrode called "Harnimoly" introduced by the Harnischfeger Corporation presents many new possibilities in the welding of parts that require machining and flame or heat treatment during the process of manufacture.

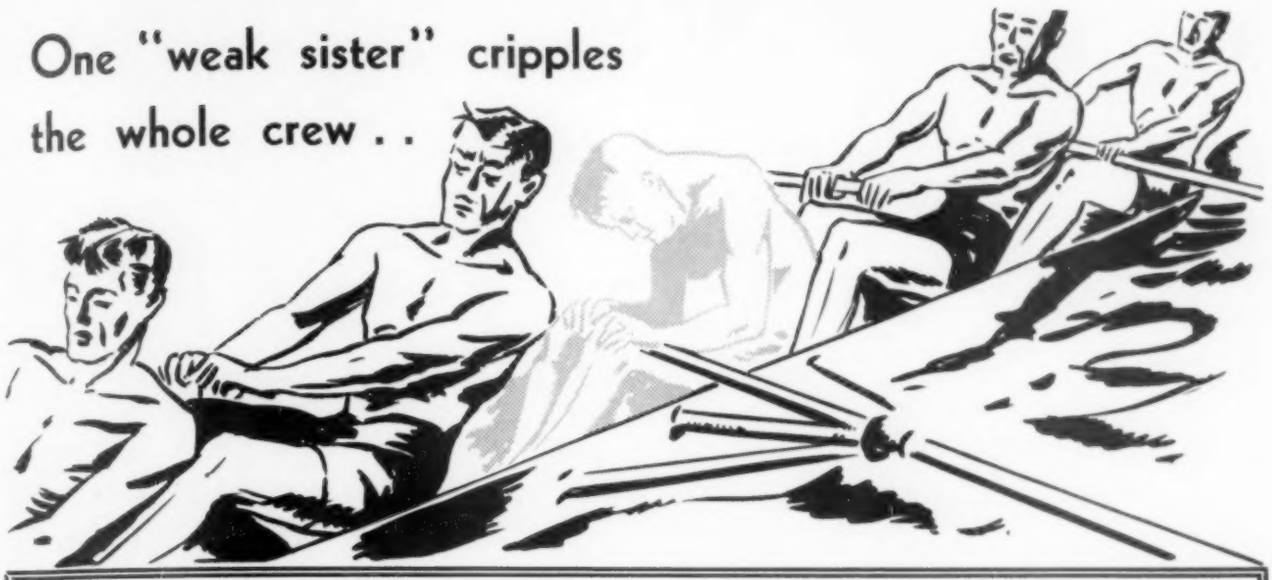
Though easily machinable in the as-welded state, the metal deposited by "Harnimoly" after flame treatment takes on the same qualities as the parent metal, giving a uniform hardness throughout.

Physical properties of "Harnimoly" (average): tensile strength, 85,000–90,000 psi; yield point, 65,000–70,000 psi; elongation in 2 in., 15–20%.

In type, "Harnimoly" is a shielded arc type electrode for welding joints and surfaces on high carbon or alloy steels that can be flame hardened up to 415 Brinell or hardened by heat treatment.

This electrode is not recommended for hard surfacing except where flame hardening or heat treatment is to be employed after welding.

Upon request the Harnischfeger Corporation, 4513 W. National Avenue, Mil-



Don't Let "Weak Sister" Resistance Welding Electrodes Slow Up Your Production

Most plants have "weak sisters" somewhere along the production line. Often they are slow and antiquated machines that hold up production. Sometimes they are inaccurate machines that cause excessive rejects. But—in many cases they aren't machines at all. The weakest of all "weak sisters" are frequently electrodes—spot welding tips, seam welding wheels, butt and flash welding dies.

If tips "mushroom" quickly, causing expensive delays for redressing and changing in your plant . . . if fast-wearing wheels, or dies that need frequent replacement, are slowing up your production . . . we suggest you change to the standardized electrode materials offered by the associate member companies here listed.

No development program in the field of resistance welding has contributed more towards saving of time and money than the R.W.M.A. standardization of electrode sizes and types. General economies have been effected in the cost of the electrodes. Appreciable savings in time are also possible, now that electrodes may be ordered out of stock without delay. Standardization has resulted in more uniform welds and in longer electrode life.

If you have a resistance welding electrode problem, consult any of the associate member companies here listed. It is certain that you will find exactly the right material for your particular operation.

RESISTANCE WELDER

MANUFACTURER'S ASSOCIATION
505 Arch Street • • • Philadelphia, Pa.

RESISTANCE WELDER MANUFACTURERS ASSOCIATION
RWMA

MEMBER COMPANIES

Taylor-Hall Welding Corporation, Worcester, Mass.
Taylor-Winfield Corporation, Warren, Ohio
Thomson-Gibb Electric Welding Co., Lynn, Mass.
Welding Machines Mfg. Co., Detroit, Mich.
Acme Electric Welder Company, Huntington Park, Calif.
Eisler Engineering Company, Newark, N. J.
Expert Welding Machine Co., Detroit, Mich.
Federal Machine and Welder Company, Warren, Ohio
Multi-Hydromatic Welding and Manufacturing Co., Detroit, Mich.
National Electric Welding Machines Co., Bay City, Mich.
Progressive Welder Company, Detroit, Mich.
Swift Electric Welder Company, Detroit, Mich.

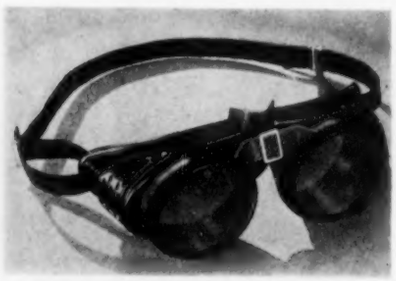
ASSOCIATE MEMBER COMPANIES

S-M-S Corporation, Detroit, Mich.
Electroloy, Inc., New York City
Welding Sales and Engineering Co., Detroit, Mich.
P. R. Mallory and Co., Indianapolis, Ind.

waukee, Wis., will send complete information on applications and procedures.

NEW ARC-BAN WELDING GOGGLE

A new line of welding goggles has just been introduced by Bausch & Lomb which have safety features not found in other similar type welding goggles. The new goggles, known as "Arc-Ban," are of the louver sideshield construction. The louvers are automatically located in such a way that there is a direct channel for air passage although all light is excluded.



The louvers are designed so that there are no projections either on the outside or the inside of the goggle which might cause abrasion or injury.

The lightweight composition cups are designed to conform to facial contours and fit all types of faces. Two models are offered to take care of workmen with corrective spectacles and those whose eyes require no correction.

SELECTOR OF PHYSICAL PROPERTIES

Ampco Metal, Inc., Milwaukee, Wisconsin, producers of Ampco Metal, is distributing a cardboard slide selector by which the physical properties and chemical composition of all grades of Ampco Metal may be quickly ascertained by manipulating the cardboard slide. The reverse of the selector contains a table listing the general uses of the alloy by grades. Thus, a prospective user with the problem of selecting a metal for a certain part can easily find those grades of Ampco usually employed in the application and then, by setting the "Selector of Physical Properties," check to discover which grade most closely meets his requirements. This "Selector of Physical Properties" will be sent free to those interested in the use of Ampco Metal.

GLASS COATER

A new material, known as Dolph's No. 253 Clear Glass Coater, is used primarily to protect welding drop lights from weld spatter.

In many shipyards production is often held up by welders' lights being broken by welding spatter. Actual tests conducted in several shipyards have proved that lamps coated with Dolph's No. 253 Clear Glass Coater long outlast untreated lamps. It is also useful for protecting porthole glass and other surfaces during construction. A film of No. 253 Clear Glass Coater prevents pitting from welding spatter. It can be removed readily when welding is completed.

Dolph's No. 253 Clear Glass Coater air dries on flat surfaces in thirty minutes. It is transparent and does not darken under heat. It is generally applied by dipping.

For information address John C. Dolph Co., Newark, N. J.

CAST-IRON ROD

The development and perfection of an unusually fine cast-iron welding electrode has been recently accomplished by the American Agile Corporation of Cleveland.

Known as the Agile Yellow Rod, it completely eliminates the necessity of preheating the object to be welded.

The weld metal deposit of this new electrode is soft and in the fusion area is not over 220 Brinell which makes it readily machineable.

Additional information will gladly be furnished by the manufacturer.

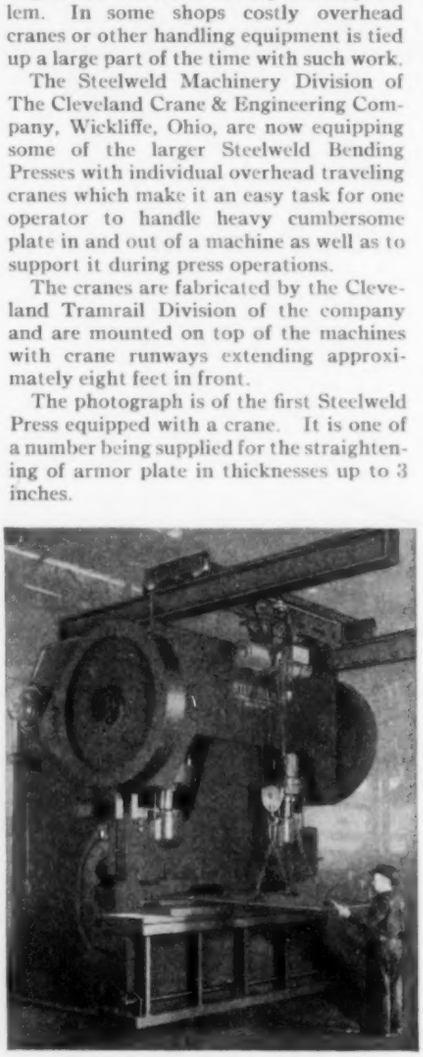
STEELWELD PRESS

The handling of heavy plate being formed or straightened in bending presses or press brakes often is a very serious problem. In some shops costly overhead cranes or other handling equipment is tied up a large part of the time with such work.

The Steelweld Machinery Division of The Cleveland Crane & Engineering Company, Wickliffe, Ohio, are now equipping some of the larger Steelweld Bending Presses with individual overhead traveling cranes which make it an easy task for one operator to handle heavy cumbersome plate in and out of a machine as well as to support it during press operations.

The cranes are fabricated by the Cleveland Tramrail Division of the company and are mounted on top of the machines with crane runways extending approximately eight feet in front.

The photograph is of the first Steelweld Press equipped with a crane. It is one of a number being supplied for the straightening of armor plate in thicknesses up to 3 inches.



The crane bridge and carrier are hand propelled. The hoist is motor-driven and controlled by means of a pendant push-button station. The hoist is of 2-tons capacity and has a hoisting speed of 26 F.P.M.

This press is also unusual in that it is provided with an especially wide bed top and ram bottom to accommodate wide dies necessary for armor-plate straightening.

This machine is known as Steelweld Bending Press Model Mo5–8 and has a normal capacity of 450 tons. It is powered with a 40 hp. motor and has a speed of 21 strokes per minute.

Employment Service Bulletin

SERVICES AVAILABLE

A-402. Graduate mechanical engineer with master's degree from a large and prominent eastern university, with a record of fundamental research in flame, D.C. arc and resistance welding methods and design, desires to make industrial connection on a full-time basis. Thoroughly familiar with testing equipment, and methods of weld analysis including metallographic and X-rays. Conversant with Welding Code for Buildings of the American Welding Society, and N. E. M. A. specifications for D.C. welding equipment. At present employed on teaching staff of a western university. Desires to change to the welding industry.

A-403. Pipe utility man. Have worked in all departments of pipe laying, including supervision, handling of welding equipment, preparing requisitions, shipping and the like. Location immaterial.

A-404. Arc welder desires position in South America, Panama or in other foreign country. Seven years' experience as welder, inspector, foreman, instructor. Worked in shipyard. Can weld in all positions. Have some experience with gas welding, cutting and thermit welding. Have passed Navy tests.

WESTERN METAL CONGRESS

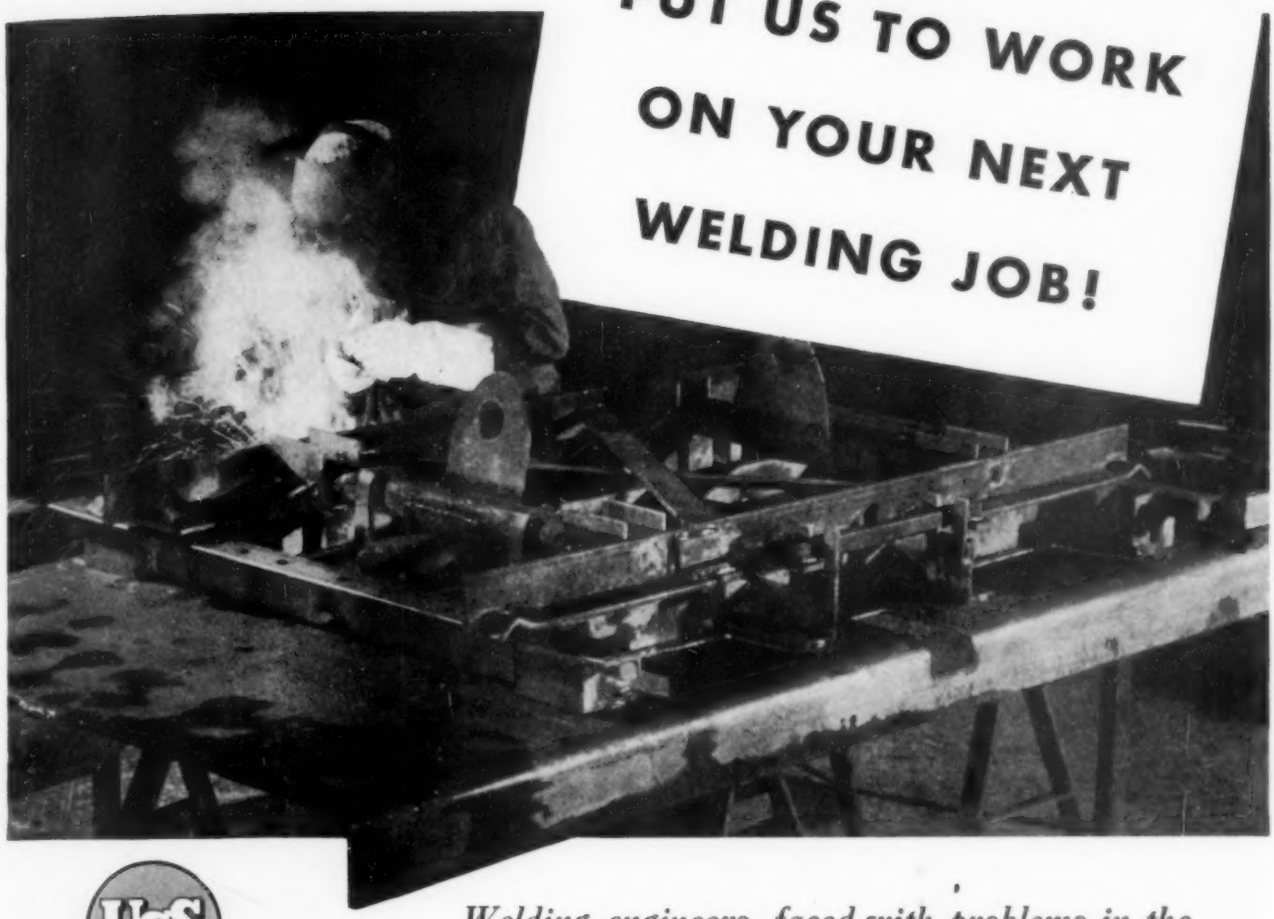
LOS ANGELES
May 19 to 23, 1941

Outstanding Technical Program

Largest Metal Exposition including Welding held in the West

See Detailed Program April Welding Journal

Plan to Attend



Welding engineers, faced with problems in the selection of special steels and how to get the best welded construction from them will find many advantages in this service.

Here are some of the U·S·S Rolled Steels which are contributing much to efficient and economical welded construction.

U·S·S Cor-Ten to resist corrosion.

U·S·S Man-Ten and **Cor-Ten** for weight reduction and corrosion resistance.

U·S·S Abrasion-Resisting Steel for use where abrasive conditions are severe.

U·S·S Heat-Resisting Steels to combat high temperatures.

U·S·S Stainless Steel to resist corrosion of all kinds and reduce structural weight.

U·S·S Carilloy Alloy Steels to carry tremendous bearing pressures.

IT'S no more expected that a welding engineer be an expert metallurgist than that a metallurgist should be an expert welding engineer. That's why we employ both.

For when we produce a special steel, the first thing we do is to determine its welding qualifications and characteristics in order to promote its widest usefulness.

That specialized knowledge equips us to offer a service to the welding industry which we believe is as important as the wide selection we offer in U·S·S Rolled Steels.

Many a welding construction job undertaken in these days of production pressure may call for rolled steel with characteristics with which you are unfamiliar. When that occurs, put the problem up to us. There's nothing we'd rather do than help you select the right steel and then show you how it can be used most efficiently.

U·S·S ROLLED STEELS *for* WELDING

CARNEGIE-ILLINOIS STEEL CORPORATION, *Pittsburgh and Chicago*
COLUMBIA STEEL COMPANY, *San Francisco*
TENNESSEE COAL, IRON & RAILROAD COMPANY, *Birmingham*
United States Steel Export Company, New York

UNITED STATES STEEL

List of New Members

February 1st to March 31, 1941

BIRMINGHAM

Christian, Joe J. (D), 1210—32nd St. No., Birmingham, Ala.
McGrann, John H. (C), Y. M. C. A., Box 704, Birmingham, Ala.
Walker, Roland E. (B), Moore-Handley Hardware Co., Birmingham, Ala.

BOSTON

Bodurtha, David A. (D), 20 So. Maple St., Westfield, Mass.
D'Arcangelo, Amelio (F), 31 Park St., Brookline, Mass.
Michand, Raymond J. (D), 499 Haverhill St., Lawrence, Mass.
Pratt, Harold R. (C), 37 Temple Ave., Winthrop, Mass.
Proctor, John C. (C), Box 41, North Weymouth, Mass.

CANADA

Gauthier, Paul E. (D), 146-B—5th St., Shawinigan Falls, P. Q., Canada.
Williamson, Frederick L. (C), 3030 Glen Dr., Vancouver, B. C.

CHICAGO

Brenstrom, Bernard W. (C), 15545 Lexington Ave., Harvey, Ill.
Cavanagh, J. O. (C), Hollup Corp., 3357 W. 47th Pl., Chicago, Ill.
Gerlach, Charles M. (D), 515 Newten Ave., Glen Ellyn, Ill.
Holland, Thomas A. (C), 7643 So. Ridgeland Ave., Chicago, Ill.
Howson, Louis Richard (B), Alvord, Burdick & Howson, 20 No. Wacker Dr., Chicago, Ill.
Jackman, C. H. (C), Carnegie-Illinois Steel Corp., 208 So. La Salle St., Chicago, Ill.
Kovalovsky, Klement (D), 4057 W. 21st Pl., Chicago, Ill.
Powell, Nick (D), Hotel Indiana, 4605 Indianapolis Blvd., E. Chicago, Ill.
Smith, Andrew B. (B), 3933 No. Keeler Ave., Chicago, Ill.
Taylor, Gordon W. (D), 5354 Agatite Ave., Chicago, Ill.

CINCINNATI

Viox, Gene M. (D), 2406 Sherman Ave., Middletown, Ohio.

CLEVELAND

Balice, Tony (D), 835 Alhambra Rd., Cleveland, Ohio.
Barber, C. Merrill (C), 2341 Carnegie Ave., Cleveland, Ohio.
Brow, James B. (B), Johnston & Jennings, 877 Addison Rd., Cleveland, Ohio.
Concar, John R. (C), 1811 E. 33rd St., Cleveland, Ohio.
Crittenden, Percy (C), Stop 47½ Broadway, Lorain, Ohio.
Evans, Edward A. (C), 1812 Roxford Rd., E. Cleveland, Ohio.
Folk, Fred H. (C), 1108 Bunker Hill Rd., Ashtabula, Ohio.
Gefvert, G. H. (C), 1835 Noble Rd., Cleveland, Ohio.
Pahlow, Irving (C), American Bureau of Shipping, 660 Rockefeller Bldg., Cleveland, Ohio.
Prince, W. B. (C), The Prince & Izant Co., 1980 E. 66th St., Cleveland, Ohio.

COLUMBUS

Lenz, John (F), Ohio State Univ., Box 181, Baker Hall, Columbus, Ohio.
Steiger, W. Selden (F), 59—18th Ave., Columbus, Ohio.

CONNECTICUT

Craig, Ernest G. (C), Malleable Iron Fittings Co., Branford, Conn.
Murphy, Matthew (C), 16 Washington St., Waterbury, Conn.

DETROIT

Boucher, A. F. (B), Lincoln Elec. Co., 10228 Woodward Ave., Detroit, Mich.
Burrows, Godfrey (B), Chevrolet Motor Co., Pressed Metal Div., Flint, Mich.
Cooper, James R. (B), Evans Products Co., 15310 Fullerton Ave., Detroit, Mich.
Diebold, John M. (C), 15358 Hartwell, Detroit, Mich.
Dunkel, John J. (B), Whitehead & Kales Co., 58 Haltiner St., Detroit, Mich.
Fulton, R. S. (B), National Time & Signal Corp., 600 E. Milwaukee Ave., Detroit, Mich.
Hance, Joseph W. (C), 2803 Maybury Grand, Detroit, Mich.
Jewett, Walter Leroy (B), 925 Kitchener, Detroit, Mich.
Kreps, Richard B. (B), 672 W. Kirby Ave., Detroit, Mich.
Marcoux, Michael L. (B), 19357 Havana, Detroit, Mich.
Michalak, George F. (D), 666 Orchard St., Wyandotte, Mich.
Overturf, Clarence A. (C), Hobart Bros. Co., 5257 Trumbull, Detroit, Mich.
Quail, Kenneth H. (B), Detroit Edison Co., 2000—2nd Ave., Rm. 340, Detroit, Mich.
Van Hove, Henry Louis (C), L. A. Young Spring & Wire Corp., 9200 Russell St., Detroit, Mich.

HAWAII

Chapson, Kenneth P. (B), Honolulu Iron Works, Honolulu, T. H.

INDIANA

Fleischer, George C. F. (C), Chapman Price Steel Co., P.O. Box 815, Indianapolis, Ind.
Myers, Robert D. (B), 4806 E. Washington St., Apt. 10, Indianapolis, Ind.
Ritter, Edgar L. (D), Chapman Price Steel Co., 3000 Shelley St., Indianapolis, Ind.

LOS ANGELES

Dorman, William J. (C), American Bureau of Shipping, 111 W. 7th St., San Pedro, Calif.
Melgord, Victor (C), Emsco Derrick & Equip. Co., P.O. Box 2098, Terminal Annex, Los Angeles, Calif.
Meredith, Russell (C), Northrup Aircraft Co., 8956 So. Manhattan Pl., Los Angeles, Calif.
Siefkin, E. R. (B), Vega Airplane Co., Engrg. Dept., Burbank, Calif.
Smith, A. Lincoln (D), 3824 So. Harvard Blvd., Los Angeles, Calif.

MARYLAND

Bailey, Robert T. (C), 6 Martin St., Annapolis, Md.
Edward, James C. (D), American Bureau of Shipping, 1001 St. Paul St., Baltimore, Md.
Hunt, Harry H. (C), American Bureau of Shipping, Mercantile Trust Bldg., Baltimore, Md.

MILWAUKEE

Eastberg, Albert M. (D), 2413 No. 64th St., Milwaukee, Wisc.
Gerszewski, Joseph (D), 6411 W. Moltke Ave., Milwaukee, Wisc.
Malmberg, Carl (C), 2026 S. 85th St., West Allis, Wisc.
Monslek, Melvin O. (C), 1517 S. 60th St., West Allis, Wisc.
Zembruski, Harry A. (D), 4072 So. Howell Ave., Milwaukee, Wisc.

NEW YORK

Augsborg, Max (B), Gibbs & Cox, 1 W. 100th St., New York, N. Y.
Betz, Carl E. (B), Magnaflux Corp., 25 W. 43rd St., New York, N. Y.
Doria, Dominic (D), 230 Riverdale Ave., Yonkers, N. Y.
Kuhn, Walter C., Jr. (C), 55 Woodmere Blvd., Woodmere, N. Y.
Lansing, Herbert S. (B), 19 E. 16th St., New York, N. Y.
Lazar, Bernard (D), 814 Howard Ave., Brooklyn, N. Y.
Morrison, Homer R. (B), 22 Beekman Ave., Mt. Vernon, N. Y.
Morrow, William J. (D), 160-03 Sanford Ave., Flushing, N. Y.
McArdle, Edward (D), 3622 Tibbett Ave., Bronx, N. Y.
Neuhaus, Benjamin (D), 200 W. 86th St., New York, N. Y.
Partiot, Maurice (B), Specialty Equip. & Machinery Corp., 230 Park Ave., New York, N. Y.
Sirugo, Joseph R. (D), 207—2nd Ave., New York, N. Y.
Wasserman, Rene D. (B), Eutectic Welding Alloys, Inc., 40 Worth St., New York, N. Y.
Waterson, Henry R. (D), 7712—66 Rd., Middle Village, L. I.
Woolever, William, Jr. (C), 344 E. 144th St., New York, N. Y.

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Shown at the right are 8 dies—used in the plant of a large motor manufacturer—which were hard-faced with Haynes Stellite No. 6 alloy. These hard-faced dies have outlasted steel dies from 3 to 6 times, and they are refitted in approximately half the time required for the ordinary dies.

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Haynes Stellite alloy is being used *profitably* on wearing parts in practically every industry. Haynes Stellite sales engineers and Linde service operators will be glad to give you practical assistance and to show you how hard-facing makes possible higher production . . . with lower costs and fewer shutdowns. Write or phone the district office nearest you.

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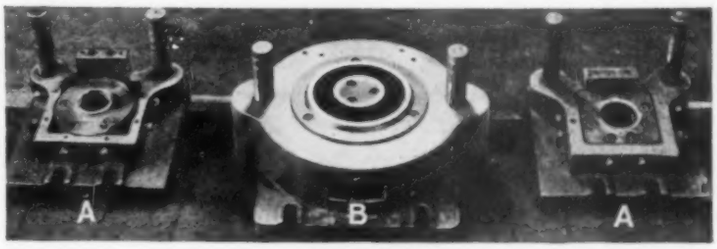
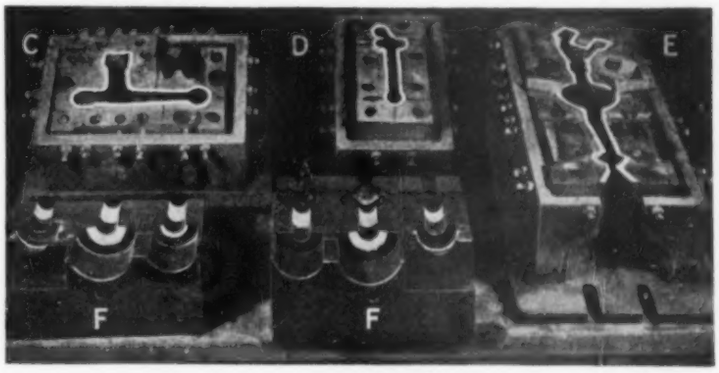
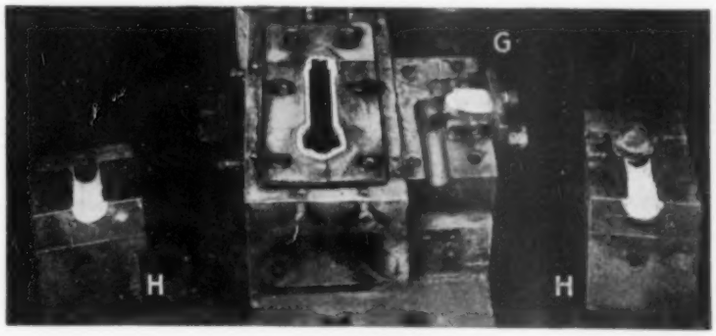
HAYNES STELLITE TRADE MARK



	No. of Pieces Between Refittings	*Hours Required to Refit Die*
A—Hot-Trimming Die for Rear Axle Differential Gear	Steel—4,000 Hard-Faced—20,000	Steel—16 Hard-Faced—6
B—Hot-Trimming and Piercing Die for Ring Gear	Steel—2,500 Hard-Faced—15,000	Steel—20 Hard-Faced—12



	No. of Pieces Between Refittings	*Hours Required to Refit Die*
C—Hot-Trimming Die for Wheel Support	Steel—2,500 Hard-Faced—7,500	Steel—16 Hard-Faced—8
D—Hot-Trimming Die for Steering Crank	Steel—1,750 Hard-Faced—7,500	Steel—16 Hard-Faced—8
E—Hot-Trimming Die for Front Wheel Support Arm	Steel—2,500 Hard-Faced—7,500	Steel—40 Hard-Faced—20
F—Upsetting Die for Pinion Gear	Steel—5,000 Hard-Faced—25,000	Steel—120 Hard-Faced—70



	No. of Pieces Between Refittings	*Hours Required to Refit Die*
G—Hot-Trimming Die for Steering Cross Shaft	Steel—3,500 Hard-Faced—15,000	Steel—28 Hard-Faced—10
H—Upsetting Die for Pinion Gear	Steel—5,000 Hard-Faced—25,000	Steel—120 Hard-Faced—70

Red-hard, wear-resisting alloy of cobalt, chromium, and tungsten.

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Boisvert, Xavier (C), Dover Boiler Wks., Dover, N. J.
Boyle, Wm. R. (D), 1209 Dean St., Brooklyn, N. Y.
Butler, Homer F. (C), 1053 Potter Ave., Union, N. J.
Cooper, Tunis (D), 560 Highland Ave., Clifton, N. J.
Enderwood, Richard (C), Davis Engineering Corp., 45 Richlieu Pl., Newark, N. J.
Ferguson, Alex A. (D), 322 E. 4th St., Clifton, N. J.
Gandet, Marcel L. (D), 6 Prospect St., Lodi, N. J.
Gelenius, Harry (D), 109 Randolph Ave., Jersey City, N. J.
Giroux, Fred J. (B), Falstrom Co., Main Ave. & D.L. & W.R.R., Passaic, N. J.
Haines, George T., Jr. (D), 12 E. Ryon Ave., Pleasantville, N. J.
Helmstetter, Richard P. (D), 138 Linden Ave., Irvington, N. J.
Horsman, Kenneth W. (B), Worthington Pump and Machy. Corp., Harrison, N. J.
Hunter, R. C., Jr. (D), 107 Halsey St., Newark, N. J.
Laterman, Edward (C), Champion Rivet Co., 30 Church St., New York, N. Y.
Mason, Leonard E. (C), 137 Bloomfield Ave., Newark, N. J.
Medoff, Jack I. (C), Worthington Pump & Machy. Corp., Harrison, N. J.
Mitchell, A. Y. (C), Standard Vacuum Oil Co., Singapore, China.
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Nolan, Patrick J. (D), 26 Lillian Terrace, Woodbridge, N. J.
O'Leary, Daniel J. (D), 56 Glenwood Ave., Jersey City, N. J.
Olin, Arthur (D), 39 La France Ave., Bloomfield, N. J.
Palughi, George (D), 17A Center St., Jersey City, N. J.
Petersen, Kenneth (D), 35 Furber Ave., Linden, N. J.
Radcliffe, Amos W. (C), 96 Prospect St., Paterson, N. J.
Shaver, John H. (C), Board of Education, 2 Harrison Ave., Jersey City, N. J.
Shaw, Frank B. (D), 129—11th Ave., Newark, N. J.
Smith, Russell W. (C), 472 Devon St., Arlington, N. J.
Tuzzeo, Joseph, Jr. (B), American Welding Schools, 15 Prince St., Paterson, N. J.
Wehrheim, Henry (C), Wehrheim Mach. Corp., 77 Ogden St., Newark, N. J.
White, Clarence (D), 24 Comfort Pl., Clifton, N. J.
Yeoman, Frank (D), 1113 Broad St., Newark, N. J.

NORTHERN NEW YORK

Haffly, Jesse B. (C), 17 Plunkett St., Pittsfield, Mass.

NORTHWEST

Miller, Frank (D), 5820—22nd Ave. So., Minneapolis, Minn.

OKLAHOMA CITY

Black, John Roy (B), J. B. Klein Iron & Fdy. Co., Oklahoma City, Okla.
Fender, William L. (F), 215 Ramsey, Stillwater, Okla.
Foster, Calvin (C), J. B. Klein Iron & Fdy. Co., Oklahoma City, Okla.
Matheny, Wm. F. (C), J. B. Klein Iron & Fdy. Co., Oklahoma City, Okla.
Smith, Stanley (C), J. B. Klein Iron & Fdy. Co., Oklahoma City, Okla.
Talbutt, D. E., Jr. (F), 125 Thatcher Hall, Stillwater, Okla.
Wallace, Paul (F), 524 Hester, Stillwater, Okla.

PEORIA

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McKee, Leo L. (D), R.R. 5, Box 558, E. Peoria, Ill.
Richardson, Edwin (D), 659 W. Grove St., Galesburg, Ill.
Tharp, Don (D), Gale Products, Galesburg, Ill.

PHILADELPHIA

Allison, Wilmer V. (C), Lot 13, Mulberry Lane, Newtown Square, Pa.
Brown, D. E., Jr. (C), 1422 Hancock St., Chester, Pa.
Daniels, Bruno A. (D), 4137 Terrace St., Rox., Philadelphia, Pa.
Gutowski, Bernard J. (C), 2928 N. Second St., Philadelphia, Pa.
Johnson, Amos G. (D), 2733 S. 16th St., Philadelphia, Pa.
Maling, George C. (C), 106 Henderson Ave., Ridley Park, Pa.
Malmesbury, Carl D. (D), Carl Mackley Houses, M and Bristol Sts., Philadelphia, Pa.
Ogden, Russell C. (D), 332 Springton Rd., Bywood, Pa.
Ramsay, William L. (C), 4857 Melrose St., Philadelphia, Pa.
Sauvageot, Walter E. (D), 4320 Manayunk Ave., Philadelphia, Pa.
Shearer, J., Jr. (C), American Bureau of Shipping, 449 Bourse Bldg., Philadelphia, Pa.
Swartfiguer, Clark (C), Glen Riddle Rd., Media, Pa.
Witmer, Stanley H. (D), Fitzgibbons & Crisp, Trenton, N. J.

PITTSBURGH

Boyer, Albert T. (C), Blaw-Knox Co., 829 Beaver Ave., N.S., Pittsburgh, Pa.
Merryman, James A. (B), 1344 Singer Pl., Wilkinsburg, Pa.
Tuppeny, Chas. W. (D), 514 Sharon Ave., Sharon Hill, Pa.

PUGET SOUND

Evans, Harry P. (C), Loucks Labs., Inc., 314 Maritime Bldg., Seattle, Wash.
Smith, J. Earle (B), Keystone Welding & Brazing Co., 309 E. Pine St., Seattle, Wash.
Stewart, S. S. (B), Columbia Marine Shipyards, Kennewick, Wash.

ROCHESTER

Stoler, Harry (C), Welding Supply Co., 510 State St., Rochester, N. Y.

ST. LOUIS

Ballman, Frederick (C), 4351 Duncan Ave., St. Louis, Mo.

SAN FRANCISCO

Bergundthal, C. J. (B), Welding Eng. Co., 431 Grove St., Oakland, Calif.
Campbell, Alvin R. (B), Alvin R. Campbell Co., 324 Main St., San Francisco, Calif.
Davidson, Perry (D), 628 Sierra Point Rd., Brisbane, Calif.
Denning, C. O. (D), 822 Clayton St., San Francisco, Calif.
Harvey, James L. (D), 453 Divisadero, San Francisco, Calif.
Johnston, R. B. (D), Edith & Oak St., Los Altos, Calif.
McCarrel, D. (D), 1 Rutland St., San Francisco, Calif.
McLean, Basil A. (B), 2520 Hale Dr., Burlingame, Calif.
Ryan, B. L. (C), 2071—19th Ave., San Francisco, Calif.
Turi, Ricky (D), 1595 Clay St., San Francisco, Calif.

SOUTH TEXAS

Boyll, F. W. (C), P.O. Box 1341, Corpus Christi, Texas.
Denney, G. B. (C), P.O. Box 3047, Houston, Texas.
Dwyer, W. H., Jr. (C), P.O. Box 2514, Houston, Texas.
Elliott, R. J. (C), 5240 Jefferson, Houston, Texas.
Ellis, Fordtran (C), P.O. Box 24, So. Houston, Texas.
Friedl, Newt F. (D), 1417 Reid St., Houston, Texas.
Loewenstern, Walter (C), 2320 Swift St., Houston, Texas.
Meusel, Paul (D), Box 83, Houston, Texas.
Pape, Henry H. (C), 4927 Leeland, Houston, Texas.
Smith, Albert K. (C), 4402 Roseneath, Houston, Texas.
Smith, B. K. (B), 1701 Milford St., Houston, Texas.
Smith, Harry (C), 2105 Swift St., Houston, Texas.
Tofte, W. L. (C), Hughes Tool Co., 300 Hughes St., Houston, Texas.
White, A. D. (B), Hughes Tool Co., 300 Hughes St., Houston, Texas.
Wilson, Charles H. (C), Houston Welding School, 3808 McKinney, Houston, Texas.
Wisler, A. E. (C), 402 Woolworth, Houston, Texas.

TULSA

Cox, Thomas E. (D), Box 456, Claremore, Okla.

WASHINGTON, D. C.

Jameson, William Scarlett (C), British Embassy, Washington, D. C.

WESTERN NEW YORK

Beebe, Henry K., Jr. (C), Bell Aircraft Corp., 2050 Elmwood, Buffalo, N. Y.
Brown, Robert L. (D), 39 W. Hazeltine Ave., Kenmore, N. Y.
Eismann, Harry (D), 352 Elm St., Apt. 3, Buffalo, N. Y.
Gaines, Bernard (B), Curtiss Aeroplane Div., Materials Lab., Buffalo, N. Y.
Grantham, William I. (C), Niagara Welding & Boiler Wks., 811 Linwood Ave., Niagara Falls, N. Y.
Stenberg, Harold K. (C), Root, Neal & Co., 64 Peabody St., Buffalo, N. Y.

WICHITA

Link, Hugh (D), 101 W. 23rd St., Hutchinson, Kansas.
Rounds, J. W. (C), The Globe Oil & Ref. Co., McPherson, Kansas.

YORK—CENTRAL PENNA.

Asbridge, Edmund M. (C), 262 Jefferson Ave., York, Pa.
Dressel, Paul L. (C), Dressel's Spring Wks., 325 Prospect St., York, Pa.
Gilbert, Joseph Henry (C), 33 E. Jackson St., York, Pa.
Kauffman, Galen (D), 145 W. Franklin St., New Holland, Pa.
Masters, F. M. (B), Modjeski & Masters, State St. Bldg., Harrisburg, Pa.
Trout, Harry E. (D), R.D. 1, York, Pa.

YOUNGSTOWN

Alexander, A. B. (B), Standard Boiler & Plate Iron Co., Niles, Ohio.
Allen, Chester L. (D), 43 N. Bella Vista Ave., Youngstown, Ohio.
Bunting, Ernest Y. (C), 785 Elm Rd., N.E., Warren, Ohio.
Goldner, George H. (D), 374 Homewood Ave., S.E., Warren, Ohio.
Kirkwood, William (C), Box 381, R.D. 1, Warren, Ohio.
May, Robert L. (D), 407 Ohio Ave., N.W., Warren, Ohio.

NOT IN SECTIONS

Baker, Kenneth H. (C), Louisville Drying Machy. Co., Inc., 451 Baxter Ave., Louisville, Ky.
Crosby, B. L. (C), Council Dredging Co., Council, Alaska.
Downey, C. J. (B), P.O. Box 5128, Jacksonville, Fla.
Eichelmann, A. F. (B), Cia. Prod. de Oxigeno de Tampico, Apartado No. 765, Tampico, Mexico.
Fogwell, Chas. S. (C), Rt. 5, Box 217, Phoenix, Ariz.
Friedmann, Martin, Jr. (C), 1005 Shirley Ave., Norfolk, Va.
Heisler, Edward R. (D), 200 E. Brookland Park Blvd., Richmond, Va.
Keele, Claude (C), Rockford Lane, Shively, Ky.
Lindsley, John Martin (C), 139 Lee St., St. Albans, W. Va.
May, Luther B. (B), 92 Smith St., Charleston, S. C.
Overturf, Ray W. (C), Gilbertsville, Ky.
Phillips, W. O. (C), P.O. Box 1820, Durban, South Africa.
Rickel, C. K. (B), Big Three Welding Equip. Co., P.O. Box 1538, Fort Worth, Texas.
Sudhop, Louis (B), New Process Welding Wks., New Hampton, Iowa.

SECTION ACTIVITIES

CHICAGO

The regular monthly meeting of the Chicago Section was held on March 21st at the Chicago Lighting Institute. Mr. N. A. Ziegler, Research Metallurgist, Crane Company, was the guest speaker of the evening. Mr. Ziegler spoke on "Weldability of Steel." A Get-Together Dinner in The Electric Club preceded the meeting.

CLEVELAND

In the "Weldformation" meeting on April 9th, the Cleveland Section treated its members to one of the most interesting and successful programs in its history.

Of the "Information Please" type, "Weldformation" was enthusiastically received by more than 100 members.

The "Board of Experts" consisted of G. N. Sieger, President and General Manager of S. M. S. Corp., Detroit, master of ceremonies; Fred L. Plummer, Consulting Engineer, Hammond Iron Works, Warren, Pa.; E. W. P. Smith, Consulting Engineer, The Lincoln Electric Co., Cleveland; and Robert E. Kinkead, Consulting Engineer in Welding, Cleveland.

The board weathered the barrage of questions with complete success with the result that they, and not the questioners, were awarded the prizes.

Questions were typed on cards and presented to the master of ceremonies before the session started. The experts were seated around a table on a platform and answered the questions over a loud speaker hook-up. Mr. Sieger kept the meeting moving along at a lively pace with his ready wit and a seeming endless supply of appropriate jokes.

Announcement was made of the election of new officers for the coming year. J. Frank Maine was elected Chairman of the section; R. J. Kriz, Vice-Chairman; and A. L. Pfeil, Secretary-Treasurer.

May 9th was the date set for the Spring Welding Conference which was repeated this year by the Cleveland Section of the AMERICAN WELDING SOCIETY as a result of the great interest shown in last year's meeting.

Designed as a clearing house for latest information on topics of interest to users of welding, this "Annual Symposium" brings together many recognized authorities. It also provides for the interchange of ideas on current questions and problems through the medium of informal discussions on the part of those who attend.

There were 2 sessions, one afternoon and one evening. In the afternoon the following talks were given: "New Developments in Oxyacetylene Welding," by A. N. Kugler, Applied Engineering Dept., Air Reduction Sales Co.; "Heat and Mechanical Stresses in Welding," by W. G. Theisinger, Director of Welding and Research, Lukens Steel Co.; and "Can It Be Spot Welded?" by R. T. Gillette, Welding Engineer, General Electric Co. Elmer E. Isgren, General Superintendent, R. G. Le Tourneau, Inc., addressed the evening session on the subject, "Welding from the Manufacturer's Viewpoint."

The large attendance at all sessions was due to the great emphasis which is being placed upon welding by the National Defense Program, and by the fact that Cleveland is one of the nation's most important centers engaged in National Defense production.

All sessions of the conference were held at Hotel Statler.

COLUMBUS

The April meeting of the Columbus Section was held on the 18th at the Fort Hayes Hotel. Mr. O. H. Jones of the Air Reduction Sales Co. presented an interesting discussion on "Oxyacetylene Welding and Allied Processes."

CONNECTICUT

Mr. James Partington, Manager of Engineering Department, American Locomotive Co., presented an illustrated talk on welding as used in construction of new locomotives, and told how welding has improved appearance and pay loads for railroads, at the March 18th meeting of the Connecticut Section.

DETROIT

Mr. J. A. Weiger, Vice-President, Metallurgical Division, P. R. Mallory & Co., Inc., discussed the subject of "Resistance Welding Electrodes—Their Design and Care" at the April 4th meeting of the Detroit Section. Mr. Weiger showed slides on how to get different types of welds and also some slides on aluminum welding for aircraft.

LOS ANGELES

The March meeting of the Los Angeles Section was held at Scully's Cafe and 65 members attended.

The meeting was opened with a very interesting talk by Bill Eisenman, National Secretary, American Society for Metals. He discussed very thoroughly the AMERICAN WELDING SOCIETY'S part in the Western Metals Congress & Exposition to be held in Los Angeles from May 19th–23rd. Mr. Eisenman pointed out that all the exposition space at the Pan-Pacific Auditorium has been reserved and attendance is expected to set a record. The main theme of the exposition will be the aircraft industry but many of the heavier manufacturers will be represented.

Mr. P. D. McElfish, Materials Engineer for the Standard Oil Company, in conjunction with Mr. A. K. Brumbaugh, Inspector of the General Petroleum Corporation, discussed all phases of welding problems in refinery welding. Both men are experts on the subject and the combined lectures crowded as much information into two hours as is possible on this subject.

MILWAUKEE

The Milwaukee Section held its March meeting on the 28th at Cudworth Post,

Sections—CHAIRMEN, SECRETARIES AND REGULAR MEETING DATES

BIRMINGHAM 3rd Fri.
CHAIRMAN—C. R. TINSLEY, U. S. Pipe & Foundry Co., Bessemer, Ala.
SECRETARY-TREAS.—W. L. POOLE, Air Reduction Sales Company, 2825 No. 29th Ave., Birmingham, Ala.

BOSTON 2nd Mon.
CHAIRMAN—P. L. P. FEYLING, Whitehead Metal Products Co., Inc., Cambridge, Mass.
SECRETARY—P. N. RUGG, 8 Eastern Ave., Wakefield, Mass.

CANAL ZONE First Tuesday
CHAIRMAN—R. E. HOLLICK, Box 1146, Ancon, Canal Zone
SECRETARY-TREAS.—JAMES G. MURRAY, P. O. Box 623, Diablo Hts., Canal Zone

CHATTANOOGA, TENN. 1st Wed.
CHAIRMAN—MARK HOLT, Chattanooga Welding & Machine Co., Chattanooga, Tenn.
SECRETARY—M. T. GLENN, 242 Oak Street, Chattanooga, Tenn.

CHICAGO 3rd Fri.
CHAIRMAN—L. S. MCPHEE, Whiting Corp., Harvey, Ill.
SECRETARY—M. S. HENDRICKS, Welding Engineer, Room 731, 506 South Wabash Avenue

CINCINNATI, OHIO
CHAIRMAN—ERIC O'HARA, Cincinnati Gas & Elect. Co., Cincinnati, Ohio
SECRETARY—R. G. FUGATE, Williams & Co., Inc., Cincinnati, Ohio

CLEVELAND 2nd Wed.
CHAIRMAN—J. F. MAINE, Republic Structural Iron Works, Cleveland, Ohio
SECRETARY-TREAS.—A. LESLIE PFEIL, Universal Power Corporation, Cleveland, Ohio

COLORADO 3rd Wed.
CHAIRMAN—J. H. JOHNSON, Johnson Supply Co., Denver, Colo.
SECRETARY-TREAS.—H. W. CREAGER, Hendrie & Bolthoff Mfg. & Supply Co., Denver, Colo.

COLUMBUS, OHIO 2nd Fri.
CHAIRMAN—J. A. FOUST, Ohio State University, Columbus, Ohio
SECRETARY—G. S. HERREN, The Seagrave Corp., Columbus, Ohio

CONNECTICUT 1st Tues.
CHAIRMAN—J. S. MILLER, New York, New Haven & Hartford R. R., New Haven, Conn.
SECRETARY—B. H. PERRY, Hartford Elec. Steel Co., 540 Flatbush Ave., Hartford, Conn.

DETROIT 1st or 2nd Fri.
CHAIRMAN—G. N. SIEGER, S. M. S. Corp., 1165 Harper Ave., Detroit, Mich.
SECRETARY—O. L. SMITH, Weldit Acetylene Co., 638 Bagley, Detroit, Mich.

GEORGIA 1st Fri.
CHAIRMAN—RALEIGH DRENNON, 357 W. Peachtree St. N. E., Atlanta, Ga.
SECRETARY—EDWARD GUILLOTT, 282 Spring St. N. W., Atlanta, Ga.

HAWAII Last Thurs.
CHAIRMAN—ROBERT A. PLAUS, W. A. Ramsay, Ltd., Honolulu, T. H.
SECRETARY—ALAN G. SLIPPER, Hawaiian Gas Products Co., P. O. Box 2454, Honolulu, T. H.

INDIANA
CHAIRMAN—WAYNE H. MCGLADE, J. D. Adams Mfg. Co., Indianapolis, Ind.
SECRETARY—E. F. GILVEAT, JR., J. D. Adams Mfg. Co., 217 So. Belmont Ave., Indianapolis, Ind.

KANSAS CITY, MO. 3rd Mon.
CHAIRMAN—N. ASHTON, Howard, Needles Tammen, & Bergendoff Kansas City, Mo.
SECRETARY— L. MORGAN, 18 W. 59 St. Kansas City, Mo.

LAKE SHORE
CHAIRMAN—A. W. WIEMANN, Armour Leather Co. Sheboygan, Wis.
SECRETARY—R. E. KING, 1308-A Hamilton St. Manitowoc, Wis.

LOS ANGELES 3rd Thurs.
CHAIRMAN—C. W. ROBERTS, Southwestern Eng. Co., Los Angeles, Calif.
SECRETARY—E. O. WILLIAMS, Victor Equip. Co., Los Angeles, Calif.

LOUISIANA 1st Fri.
New officers not yet selected.

MARYLAND 3rd Fri. except April
CHAIRMAN—R. A. MANSFIELD, Southern Oxygen Co., Baltimore, Md.
SECRETARY-TREAS.—W. M. H. BALLATYNE, 1408 Lexington Bldg., Baltimore, Md.

MILWAUKEE 3rd. Fri.
CHAIRMAN—R. E. BOECK, 3889 N. 4th St., Milwaukee, Wis.
SECRETARY—GILBERT F. MEYER, Machinery & Welder Corp., Milwaukee, Wis.

NEW YORK 2nd Tues. except when Joint Meeting is held
CHAIRMAN—J. T. PHILLIPS, Foster Wheeler Corp., Carteret, N. J.
SECRETARY—WAYNE A. HOWARD, Socony-Vacuum Oil Corp., Brooklyn, N. Y.

NORTHWEST 3rd Wed.
CHAIRMAN—T. P. HUGHES, University of Minn., Minneapolis, Minn.
SECRETARY—ALEXIS CASWELL, Manufacturers' Assoc. of Minn., 200 Builders Exchange Bldg., Minneapolis, Minn.

NORTHERN NEW JERSEY
CHAIRMAN—F. C. FYKE, Standard Oil Development Co., Elizabeth, N. J.
SECRETARY—H. S. CARD, 449 Elmora Ave., Elizabeth, N. J.

NORTHERN N. Y. Last Thurs.
CHAIRMAN—W. C. HUTCHINS, General Electric Co., Schenectady, N. Y.
SECRETARY—W. W. CHURCHILL, General Electric Co., Schenectady, N. Y.

OKLAHOMA CITY 1st Fri.
CHAIRMAN—K. B. BANKS, P. O. Box 1377, Oklahoma City, Okla.
SECRETARY—F. SPREHE, Midwest Steel Co., Oklahoma City, Okla.

PEORIA—CENTRAL ILLINOIS
CHAIRMAN—WALTER J. BROOKING, R. G. Le Tourneau, Inc., Peoria, Ill.
SECRETARY—ALBERT A. LOSCH, R. G. Le Tourneau, Inc., Peoria, Ill.

PHILADELPHIA 3rd Mon.
CHAIRMAN—A. J. RAYNO, Baldwin Locomotive Wks., Philadelphia, Pa.
SECRETARY—K. W. OSTROM, Arcos Corp., 401 N. Broad St., Phila., Pa.

PITTSBURGH Middle Wed.
CHAIRMAN—G. F. WOLFE, Dravo Corp., Engineering Wks. Div., Pittsburgh, Pa.
SECRETARY—J. F. MINNOTTE, Minnotte Bros., 1201 House Bldg., Pittsburgh

PUGET SOUND
CHAIRMAN—G. M. MCBRIDE, Air Reduction Sales Co., 3623 East Marginal Way, Seattle, Washington
SECRETARY-TREAS.—R. S. RUSSELL, Hydraulic Supply Co., 7500—8th Ave. South, Seattle, Wash.

QUAD CITIES
CHAIRMAN—A. R. GUSTAFSON, 840 Third Ave., Moline, Illinois
SECRETARY—J. W. SHUGARS, Lincoln Elec. Co., Moline, Illinois

ROCHESTER, N. Y. 1st Thurs.
CHAIRMAN—FRED L. PEIFFER, 1029 Lyell Ave., Rochester, N. Y.
SECRETARY—PAUL W. JAMES, Lincoln Electric Co., 17 Lake View Park, Rochester, N. Y.

SAN FRANCISCO Last Fri.
CHAIRMAN—H. CHANEY, Bethlehem Steel Co., San Francisco, Calif.
SECRETARY—J. G. BOLLINGER, Air Reduction Sales, Park & Halleck Sts., Emeryville, Calif.

SAN JOAQUIN VALLEY
CHAIRMAN—G. D. ATMORE, 401 Santa Barbara St., Santa Paula, Calif.
SECRETARY—H. S. NIX, Taft Union H. S. & Jr. College, Box 1364, Taft, Calif.

ST. LOUIS 2nd Fri.
CHAIRMAN—L. H. DODD, American Inst. of Steel Const., 1405 Paul Brown Bldg., St. Louis, Mo.
SECRETARY—M. B. SCIOLETICH, Combustion Engrg. Co., Heine Boiler Div., St. Louis, Mo.

SOUTH TEXAS
CHAIRMAN—G. W. WOODS, Hughes Tool Co., Houston, Texas
SECRETARY—W. H. GREER, Box 175, Houston, Texas

TULSA, OKLAHOMA
CHAIRMAN—F. A. HOFFMAN, Tulsa Boiler & Mach. Co., Tulsa, Okla.
SECRETARY—JAMES B. DAVIS, Tulsa Testing Labs., Tulsa, Okla.

WASHINGTON, D. C. 2nd Tues.
CHAIRMAN—C. A. TREXEL, Bureau of Yards and Docks, Navy Department, Washington, D. C.
SECRETARY—E. BROOKER, 129 South Buchanan St., Arlington, Va.

WESTERN NEW YORK Last Mon.
CHAIRMAN—G. M. TREFTS, III, Farrar & Trefts, Inc., Buffalo, N. Y.
SECRETARY—D. W. PATTERSON, Federal Mach. & Welder Co., Buffalo, N. Y.

WICHITA, KANSAS
CHAIRMAN—H. CHRISTOPHER, 1220 Blane St., Wichita, Kans.
SECRETARY-TREAS.—K. O. HOUSER, Kansas Gas & Electric Co., Wichita, Kansas

YORK—CENTRAL PENNA.
CHAIRMAN—E. J. BRADY, Alloy Rods Corp., 501 Prospect St., York, Penn.
SECRETARY—C. B. Herrick, 628 S. Pershing Ave., York, Pa.

YOUNGSTOWN (OHIO) 2nd Mon.
CHAIRMAN—J. D. GORDON, Taylor-Winfield Corp., Warren, Ohio
SECRETARY-TREAS.—A. L. WILLIAMS, Federal Machine & Welder Co., Warren, Ohio

American Legion. An after-dinner talk was given by C. C. Crouse, Passenger Agent, Union Pacific Railroad, on "Colored Pictures of Zion, Brice and Grand Canyons." The welding address was given by Dr. Charles W. Briggs, Steel Founders Society of America, on "Steel Castings and Welded Structures."

NEW YORK

The April Meeting of the New York Section of the AMERICAN WELDING SOCIETY, held on the 15th in the Engineering Societies' Building in New York City was addressed by Mr. Claude Joseph Holslag, President and Chief Engineer of the Electric Arc Cutting and Welding Company of Newark, N. J. His subject was "Improvements in Welding by Means of Preheating." Mr. J. T. Phillips, Chairman of the New York Section, opened the meeting and Mr. E. Vom Steeg, Jr., Welding Specialist of the General Electric Company of New York City presided as Technical Chairman.

Mr. Holslag described the procedure he recommends for avoiding the customary welding difficulties encountered in fabricating with alloy steels. Both shop and field practice and installations of electric preheating were well illustrated by interesting slides and motion pictures, demonstrating that his procedure extends the use of alloy welding to high tensile steels in field work in all weather conditions, allowing erection jobs to be conducted with shop procedure. A very interesting technical discussion followed in which many members of the audience took part.

It was announced that at the May 6th meeting, Mr. J. H. Deppeler, Chief Engineer of the Metal and Thermit Corporation of New York City will present a talk on the "Modern Aspects of Thermit Welding."

A dinner and business meeting of the Executive Committee at 6:30 P. M. preceded the technical session.

NORTHERN NEW JERSEY

Announced as the welding event of the mid-winter season, the Welding Exhibit of the Northern New Jersey Section, at Newark, N. J., on March 21st–22nd, developed into a well balanced success. For two days the crowds of visitors kept the Terrace Room of the Mosque Building comfortably filled from noon until 10:30 P.M. The total attendance was estimated to be in the neighborhood of 4000, and it was evident from the registration data that the visitors were all closely associated with welding operations.

A particularly notable feature of the Exhibit was the interest and care which the exhibiting firms showed in arranging their booths. The announced purpose of the event was to make it educational in character so that welding operators and welding executives from the varied industries of the New Jersey industrial area could have a close-up view of important recent developments in the welding art. The exhibitors cooperated to the extent that practically all of the exhibits were especially planned for this. The displays were not limited to equipment and materials. There were plenty of working demonstrations where processes could be observed and studied in operation. There were also exhibits of local industrial firms which showed how large-scale welding operations are carried out and displayed up-to-date procedures for inspecting welds, for controlling quality of welds, for qualifying operators and for studying the effects of weld designs and welding procedures.

The exhibiting firms were: Struthers-Wells Co., Faituoute Iron & Steel Co., Croll-Reynolds Co., Willson Products, Inc., Goetze Gasket & Packing Co., General Electric X-ray Corp., Chicago Bridge & Iron Co., The Linde Air Products Co., Chas. W. Krieg Co., Westinghouse Electric & Mfg. Co., Eisler Engineering Co., A. O. Smith Corporation, Hobart Brothers Co., Lenape Hydraulic Pressing & Forging Co., M. W. Kellogg Co., Electric Arc, Inc., Handy and Harman, Midwest Piping & Supply Co., Ransome Concrete Machinery Co., The Dallett Co., Hollup Corporation, Lincoln Electric Co., Buffalo Tank Corp., Taylor Forge & Pipe Works, Industrial School of Welding, Harris Calorific Co., Mechanical Industries Technical Inst., International Nickel Co., Federal Shipbuilding & Dry Dock Co., Welding Engineering Sales Corp. (General Electric Co.), L. O. Koven & Brother, Inc., Arcos Corporation, Metal & Thermit Corp., Joseph T. Ryerson & Son, Inc., Air Reduction Sales Co., Grammer, Dempsey & Hudson, Inc., The Watson-Stillman Co., Rubicon Company, Steel & Alloy Tank Co., Mine Safety Appliances Co., Eutectic Alloys Co.

The management of the Exhibit was handled by the following Exhibit Committee: Chairman, W. H. Hart, Chas. W. Krieg Co.; Vice-Chairman, Alexander Kidd, M. W. Kellogg Co.; Exhibits, F. C. Fyke, Standard Oil Development Co.; Rules and Regulations, H. H. Moss, The Linde Air Products Co.; Services, M. F. Sheely, Standard Oil Development Co.; Registration, T. B. Smith, Federal Shipbuilding & Dry Dock Co.; Publicity, H. S. Card, Secretary of the Northern New Jersey Section.

The regular monthly meeting was held on April 15th in the Oxford Room of the Essex House, Newark. The meeting was preceded by a dinner at the Essex House, Starlight Terrace dining room at 6:30. "How Stress Concentrations are Revealed by Polarized Light" was presented by F. E. McAtee of the Chicago Bridge & Iron Co. "X-Rays in the Pressure Vessel Plant"—Part II of Mr. McAtee's lecture described the methods of using X-ray inspection on vessels subject to code regulation. "X-Rays—Their Nature and Behavior" was given by H. S. Akers of Kelley-Koett Mfg. Co. Inc. This was a non-technical explanation of what X-rays are. Mr. Akers also demonstrated with a portable X-ray machine and fluoroscope.

NORTHWEST

The eighth and last meeting of a non-technical course on welding given by the Northwest Section took place on Wednesday, April 16th. Mr. John Mikulak, Mechanical Engineer, Electric Machinery Mfg. Co., spoke on "Welding of Machinery." After the lecture the meeting adjourned about 9:00 P.M. to the plant of the Electric Machinery Mfg. Co., to inspect the company's new welding building and its welding operations.

OKLAHOMA CITY

Mr. Orville T. Barnett of the Metal and Thermit Corporation, New York, formerly Chairman of the Oklahoma City Section, was the guest speaker at the dinner meeting held on April 10th. Mr. Barnett's subject was "Procedure Control of Welding."

Exhibits at Northern New Jersey Section

PHILADELPHIA

The Philadelphia Section held its regular monthly meeting at the Engineers' Club on April 21st. Mr. L. L. Neebe, Product Engineer of The Baldwin Locomotive Works, spoke on the subject "Electrical Welding of Railway Equipment."

PITTSBURGH

Mr. J. H. Cooper, Welding Engineer of the Taylor-Winfield Corporation, Warren, Ohio, addressed the Pittsburgh Section, Wednesday, March 19th on the subject of "Fabrication of Machine Tool Bases by Arc Welding."

The discussion covered the design and shop procedure for fabrication of machine tool bases, stressing factors affecting strength, vibration resistance, appearance and machining of product, as well as preparation of steel and flow through manufacturing processes.

Slides were used to illustrate the talk following which many questions were asked Mr. Cooper by members and guests present.

PUGET SOUND

On March 31st at the 40 and 8 Club, Seattle, Wash., Mr. G. N. Sieger, national authority on resistance welding, and President of the S. M. S. Corporation, Detroit, presented an interesting talk on "Resistance Welding." Dinner preceded the meeting.

ROCHESTER

The April meeting of the Rochester Section was held on the 3rd at Todd Union, University of Rochester. Mr. Russell Franks, Welding Engineer, Union Carbide and Carbon Co., was the guest speaker. His subject was "Welding and Corrosion on Welding of Stainless Steel."

ST. LOUIS

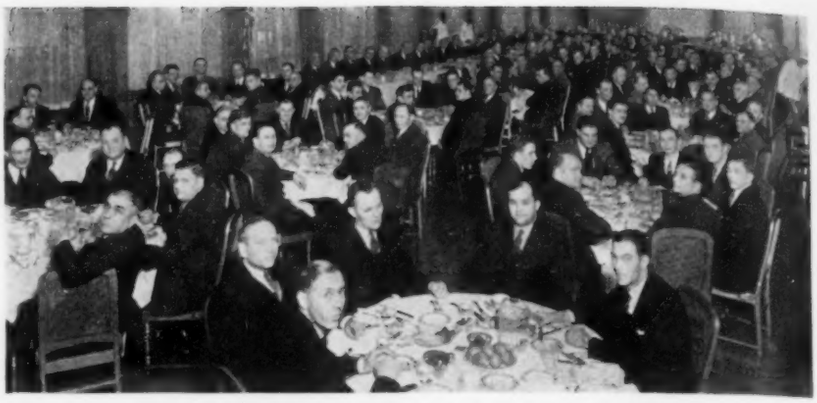
Mr. John W. Sheffer, Electrical Engineer, American Car and Foundry Co., read a paper, entitled "Application of Welding Construction to Passenger and Freight Cars" at the April 11th meeting of the St. Louis Section. Mr. Sheffer outlined the advantages which have recently been made in setting automatic spot welding to work on a truly mass production basis.

SAN FRANCISCO

Mr. G. N. Sieger of the S. M. S. Corporation, Detroit, spoke at the March 22nd meeting held at the Athens Athletic Club, Oakland. Mr. Sieger's subject was "Resistance Welding." Through the courtesy of Mr. Lee Delhi, General Manager of the Western Pipe & Steel Co., there was a preview of a technicolor film on Electric Welding in Shipbuilding. This was the first public showing of this film.

SOUTH TEXAS

There were forty interested people at the first lecture of the Educational Course on Welding Metallurgy, held on March 24th. Mr. Alex Vallance of Reed Roller Bit Company gave a good talk on the various methods of steel manufacture, and answered questions in a general discussion before the meeting adjourned.



Second Annual Banquet, York-Central Penna. Section

TULSA

Mr. Orville T. Barnett, Engineer of Tests of the Metal and Thermit Corporation, presented an interesting lecture on "Procedure Control of Welding," which was illustrated with motion pictures and lantern slides, at the April 11th meeting held at the Mayo Hotel.

WASHINGTON

The sixth regular meeting of the Washington Section was held at the auditorium of the Potomac Electric Power Company on March 25, 1941. The speaker, Mr. Donald Corey of the Detroit Edison Company, delivered a very interesting, informal talk on the subject, "The Use of Welding in Power Plants and in the Construction of Power Plant Equipment." He described the extensive applications of welding in construction of buildings, cars, piping and machinery. Design and use of chill rings for piping was discussed. Facilities for local stress-relief heat treatment of welded piping by means of induced currents were described. Resistance preheating for welding of piping was also detailed.

WESTERN NEW YORK

The Western New York Section of the AMERICAN WELDING SOCIETY held their March 21st meeting at the Hotel Buffalo. This was a dinner, followed by a business meeting, with Mr. Ben L. Wise, Chief Electrical Engineer, Federal Machine & Welder Company, Warren, Ohio, speaking on "The Possibilities of Resistance Welding in the National Defense Program."

The talk was well illustrated with samples and slides, showing the different types of work that can be done by resistance welding.

There were 125 members present at this meeting.

YORK-CENTRAL PA.

The March 19th meeting was the occasion of the second annual banquet of the Section. There were 175 guests and members present. Chairman, E. J. Brady, acted as Toastmaster and introduced guests at the speaker's table. Past-Chairman John W. Hennessey and the present Chairman of the Maryland Section, Roy A. Mansfield, gave short talks. Following this was some very fine entertainment which lasted for one hour.

The guest speaker of the evening, Mr. J. C. Hodge, Vice-President of the Wellman Engineering Company, Cleveland, Ohio, gave a very fine talk on "Fundamentals of Arc-Welding." Mr. Hodge illustrated his talk with a fine set of slides

YOUNGSTOWN

The April meeting of the AMERICAN WELDING SOCIETY, Youngstown Section, was held Tuesday, April 1st at the Federal Machine and Welder Company in Warren, Ohio. The program was divided into three parts. First, Mr. J. W. Meadowcroft, Assistant Works Manager of the E. G. Budd Company, Philadelphia, outlined the growth of resistance welding, especially in relation to the fabrication of stainless steel. The second speaker, Mr. J. McKinney, also of E. G. Budd Company, gave a very interesting discussion on shot welding of stainless steel. This discussion was illustrated by a large number of slides, which included metallographic specimens, heat and time graphs, photographs of some of the equipment used to do their welding, and finally, a number of articles of manufacture; such as truck-trailer bodies, rail cars, etc.

The third speaker of the evening was Dr. Comfort Adams, who spoke on "World Conditions Today."

The second part of the evening was devoted to a complete inspection of the plant of the Federal Machine and Welder Company. The guests were taken through the assembly and machine shop, then into the experimental department, where a number of different types of welding was demonstrated, including stored energy welding of aluminum, flash welding of brass strips, and conventional seam welding with electronic control.

The third portion of the evening was the social period, with refreshments being served.

The meeting was very well attended—in fact, there were about 250 present—the largest attendance at any Youngstown Section meeting so far.